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The dispatching system in Italy, (1)

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The scientific organisation of labour, the essential foundation of industrial prosperity, should only require of the machines and the men what they are capable of doing, an excessive demand detracting both from the quality and the quantity of production.

Our organisation of duties in the stations is not exempt from such faults. Frequently several men are employed where one would suffice; on the other hand an employee with too many duties to cover and too great responsibility to bear finds his work trying to do and consequently his output is of mediocre value. As such an organisation no longer complies with modern ideas, and is neither rational nor practical, it affects the activity of the best men, making it even ineffectual and interferes with the financial operating results.

A more rational distribution of duties and responsibilities is therefore needed, a distribution based upon the exact determination of the maximum output of the men : in this way the cost will be reduced and the individual output increased.

When the intensity of the traffic at the stations does not exceed the average and there are long periods of normal service, the duties of the operating staff may appear easy, and to be nothing more than being ready if required : but if it is noted that the stationmaster even in the smallest stations has to be ready at all times to take the necessary steps to maintain or restore regular running of the trains (by holding up slow trains so that fast trains closely following may pass, or again by changing the passing point of trains — when through the lateness of one of them this should be done), it will be appreciated the supervisory duties of the operating employee is neither so simple nor so easy.

None the less if the stationmasters at the small stations had only to watch the train working they would have little to do and this would adversely affect the cost of working. It has therefore been found reasonable to put upon the stationmaster other duties additional to his chief duty whilst at the same time making his work easier by improving the equipment. At the present time the train working no longer forms the stationmaster's first consideration.

(1) Translated from the French.

These other duties are often detrimental to the regularity of the train working; in fact when the working becomes difficult, either through irregularities in the timings of the trains out on the line or through unexpected accidents, the stationmaster is so taken up by matters of all kinds that he is unable to give sufficient time to getting the working back to proper order, or can only devote time at intervals so that the difficulties instead of being quickly overcome, become aggravated and more involved.

Furthermore, the great responsibility laid on the stationmaster as regards regular running of the trains makes his administrative work less thorough and more irregular, although this work in view of its importance needs the careful attention of specialised men who can never be suitably replaced by men on the operating side.

It is obvious that if the control of train movements now allotted to the various stationmasters along the line, who cannot follow it as a whole, were centralised by a train dispatching system at a very limited number of posts fitted with perfected modern equipment, a very much reduced number of men solely occupied with the running of the trains would be able to ensure regularity in working better than a large number of stationmasters overburdened with work and very diversified duties.

The dispatching system has been applied in Italy in two different methods : one, known as *dirigente centrale* (central controller), in all ways like the Belgian dispatching system; the other, on lines with little traffic, is known as *dirigente unico* (single controller) because the working on the lines themselves is covered by a single controller, that is to say the dispatcher. The whole of the administrative staff was released from its duties and was moved and used elsewhere, the stations being put in charge of *assuntori* (contractors) who have nothing to do with the operating but are solely concerned with administrative duties.

These stations are called *assuntorie* : the shunting thereat is done by the staff of the trains acting under the orders of the single dispatcher who by means of the selector telephone regulates the shunting in the stations and the running of the trains by transmitting to the guards the necessary orders whilst they are standing in the stations.

The dispatching system is of really capital importance for the future of our railways and yet this innovation introduced on our system two years ago by a test of the single dispatcher on the *Urbino-Fabriano* line and the central dispatcher on the *Bologna-Pistoia* line and subsequently of the single dispatcher on certain lines in Sicily, Tuscany and Piedmont, has not been appreciated and valued according to its actual importance; it is even spoken of ironically, and the system meets with both indifference and hostility.

All this is entirely unjustified : the dispatching system is for the operating official what the interlocking in the central signalling and point operating boxes is for the pointsmen : it represents technical progress, a betterment, and a great benefit for the regularity and the speed as well as for the safety of the service.

The operating employee who has had to carry on alone under all, either easy or difficult, situations the whole responsibility and the whole of the difficulties, is not disposed to agree to an innovation which appears to him to detract from his ability and regards the dispatching system with dislike and bitterness; he is afraid that as his work is in future sub-

ordinated to the management, to the control and to the orders of others, he will be deprived of that freedom of decision he has always strenuously fought for, and that, thus reduced in importance, his position of command will become a position the holder of which has to carry out orders.

To question the merit of the station masters or to slight them would be quite unreasonable.

With the dispatching system the control of train movements always remains in the hands of the operating staff, but this staff only retain of their professional and technical duties the part of the greatest merit and value.

As today we have pointsmen in the central point-operating boxes and pointsmen for hand-operated points, and as one place does not reduce the importance of the other, in the future there will be dispatchers and in addition as at present, assistant-stationmasters at the more important stations : and as the staff can become dispatchers and assistant-stationmasters, each in accordance with his preference, the individual as well as the collective interest remains guaranteed.

The work of a stationmaster is at present undergoing evolution with the inevitable changes made in his station. The laying of double lines more generally, the extension of the block system, the extension of interlocking of signals and points have made the work easier than when most of the lines were single, when the spacing and safety of trains depended entirely on the memory and carefulness of the staff, and when the correct position of the points both near and far away were only guaranteed by the many and continual visits of the assistant-stationmaster.

The smaller power of the locomotives and the frequent crossing places made it impractical to run trains long distances without frequent stops and, with a slow succession of trains limiting the intensity of movement, the stationmaster was able, with little material assistance, thanks to his own activity, to regulate the working between the stations. Against this, now that double lines and locomotives of increasing power have eliminated any necessity for frequent stops and the block system has reduced to a minimum the interval between trains, thereby making it possible to run an intensive train service, the stationmaster can often handle difficult situations which formerly would have been considered insoluble in view of the inadequate and out of date equipment he had to use.

The express train leaving one station for another several hundreds of miles away without intermediate stops only seems to the intermediate stations like a meteor which arrives and passes, leaving stations behind as though it had sown them all along the line.

It is therefore easily understandable that to regulate the running of the trains, much better equipment must be available than that in our stations, together with a quickness of action which cannot be expected, especially of the secondary stations.

The autonomy of such stations delays and impedes the steps taken to maintain or regularise the service; a lack of decision at a single station can in fact completely disorganise the train movement over the whole line.

The possibility of action of several secondary stations is so little that even on lines with heavy traffic, whilst the trains are running, the stationmasters and assistant-stationmasters can be freed from operating duties, for certain periods during which their presence at the

trains is not required, for local administrative purposes.

At all these centres the stationmasters and assistant-stationmasters have so little to do with the train working that it does harm to their professional proficiency and makes them more and more less capable and less ready to act in the event of accidents and sudden emergencies.

It should be possible straight away to eliminate these stations as they are a source of waste and a hindrance to the regularity and speed of working.

The possibility of a large reduction of posts is a further cause of the hostility of the men towards the dispatching system; they should on the contrary realise that with the elimination of every unimportant post — which no stationmaster or assistant can covet — and the creation of really important posts for directing the running of the trains, their duties have much greater merit and value.

It should also be appreciated that, as every industrial and economic organisation through the impulse of progress, which is the source of improvement and the life of the business, has continually to modify itself and to better itself if it is to develop and prosper, it would be absurd to pretend that our railways can or ought to be above this law and this duty.

Of the two different methods of application of the dispatching system under test on our lines, that of the *single controller* produced economies immediately, as a result of which it is being extended daily : a system of this kind is however only applicable to lines of light traffic and if installed too generally would reduce the industrial and strategic value of the railway and is not to be recommended.

The method of the *central controller* gives a dispatcher, through the cooperation of the traffic staff, much greater capability and power of action than the single controller system : this is why of the two methods the most efficacious is undoubtedly that of the *central controller* now being tested on the *Porrettana* (Bologna to Pistoia line, part of the main internal trunk system running through Italy).

If one wishes to detract from this test by saying that the trains over the Porrettana always ran perfectly even before installing the dispatching system, it may be remarked that this test was made not because the traffic staff had no longer any reserve capacity to use and could not regulate the traffic, but to experiment with the system on a single line which was one of the most difficult to operate and which had a heavy traffic.

The advantage of the new system may appear less obvious because before putting the dispatching system into operation the Porrettana line can be said to have been in specially good condition : in fact through the difficulties due to its layout this line has always been operated by very capable operating staffs, and owing to its importance as a main artery it has always been provided with additional telephones found on no other line; lastly, the work of the stationmaster was never too heavy because at the most difficult stations on the rising gradient the local traffic is small and consequently no duties outside the movement of the trains have to be performed.

However this may be, if the operating staff can state they have always been master of the job, nobody can fail to recognise that the dispatching system daily confirms the great efficacy of the system by which the work of the operat-

ing staff has been reduced and made easier and by which the capacity of the line can be largely increased to a level to which without the dispatching system it could never have reached. A very striking demonstration of the real utility of the dispatching system was given during the exceptionally heavy falls of snow last winter, when it made it possible to meet in an admirable manner the very great difficulties which would have been insurmountable in any other way.

The test of a train *regulator* on duty on the area between the junction of the lines radiating from Bologna has been said to be of no value as the assistant-stationmaster regulated formerly and just as satisfactorily the reception, the dispatch, and the movement of the trains.

This test gives no great signs of its importance because in fact Bologna C. station was then so well equipped with telephones that this station was a small regulating station in embryo.

The new organisation of Bologna C. may appear as a duplication of the old system or a superimposition of the new on the old, owing to the very limited extension of its functions and of its sphere of activities at the end of the first stage of the test, thereby playing into the hands of the detractors of the dispatching system. The incredulous were not long in realising their error on seeing the facility and rapidity with which the new organisation could be extended until it could equally well follow the working inside Bologna-Formation so far as concerns the state of the sidings, the reception of trains, and the work at the shunting hump.

By a similar and very interesting extension it was possible to study in Italy, in a practical manner, the system of regulation of the whole working of the large shunting yards, the wonderful organisation of which in Belgium demonstrates that for such stations it is the most rational and perfect system of the scientific organisation of labour.

Whatever judgment may be formed on the tests of the dispatching system tried so far in Italy, it must be admitted that they have completely demonstrated the real aptitude for the duty of dispatcher of men who have only carried out previously the duties of assistant-stationmasters. How far would not the Italian operating staff (which even during the ante-fascist regime, when the stations and lines were left almost entirely without equipment, did miracles) go with the dispatching system which, by enlarging their possible action and their power, would multiply the output resulting from their ability and their professional qualities ?

The role of the operating officer is one of command and of great responsibility, the value of which under the present regime has been unduly reduced by making him cover all duties, even the least important and holding him always at the mercy of his subordinates by requiring him to answer personally for their actions without giving him the means of supervising them so that if they work badly or carelessly he can be charged with laziness or negligence, even when he always works as hard as he can.

The multiplicity of his duties very often upsets his work; he can suddenly be interrupted in his train of thought by some one who meets him, by another who asks his opinion, by a case which makes him hasten to a place in the opposite direction to that to which he was hurrying.

Very frequently, in the most difficult moments, he has to take decisions on

the spot even before he has really understood the actual position of the working; or he has to leave it to his subordinates, or discuss it with them, or alter or cancel orders already given, applying contradictory solutions and alienating the professional consideration and esteem of his juniors, who are ready to ascribe to incapability, his inability to carry out his proper duties.

On the other hand, the dispatcher is solely responsible for the running of the trains and at his control, to which the other men are not admitted, where he has all necessary equipment, he is at every moment informed of the position on the line as shown on the graph of the running of the trains he prepares as they go forward; he can with the greatest calm and the most absolute independance give very precise and sure orders no one can discuss and which each man has to carry out promptly on his own direct responsibility.

The *dispatching* moves the traffic staff into the post most suitable for each man, it gives the strong characters the means of tackling and overcoming all the exigencies and difficulties of the service and, by leading automatically to the elimination of the least capable, it forms a system of selection which complies with the postulates of Fascism which wishes a free path only to those deserving of it.

If the *central controller* system is more efficient and has greater powers of action than that of the *single controller*, why is the single controller system being steadily increased on the Italian railways, whilst the *central controller* system remains at its initial point ?

It is due to the *single controller* with his method of working as set out for our railways corresponding so perfectly to the requirements of lines with little traffic for the working of which it was expressly designed and because it produced immediately after its introduction a very appreciable saving.

The *central controller* needs on the contrary, before it can be used, a much greater expenditure because of the increased number of men required for the dispatcher's office and can only show savings after some time, which savings, as they cannot be evaluated mathematically, have little weight.

It may also be remarked that the Belgian system as introduced in the Porrettana is not suited to most of our lines which, unlike the Belgian lines, have not got a heavy traffic almost uniform over the whole journey, but are composed of sections of different density and which serve many places both industrial and agricultural in which most of the trains have to stop owing to local requirements.

The Italian Railways naturally do not desire to introduce train dispatching only on lines with light traffic nor to give up the idea of finding a more suitable method of dispatching which will guarantee regular working with an appreciable saving of cost.

The operating service of the station can be considered as being divisible into two parts, the first having to do with the movement of trains running over the line and running either for their reception or for passing through or for holding them on crossing over trains, on to the main lines and the working lines of the station, the second dealing with shunting which does not affect the running of the trains directly and which is done on the sidings and fans set aside for marshalling trains and for the inside and local working of the station.

Of these two tasks, the former is the heavier as it demands constant attention and continual vigilance which must not

be interrupted nor deferred. Naturally this absorbs the greater part of the stationmasters' energies.

The present organisation of dividing the work between several stations not far apart makes use of several men who have to watch over, at the same time, the running of the same trains over the same line.

Seeing that the dispatching system gives unity of command, why should we not endeavour to find some means of using it so as to eliminate the multiplication of work with its attendant cost in staff in places where this staff is only needed because of the scattering of the management staff ? Is there any reason for not extending the dispatcher's functions to the control of the train movements within station limits at intermediate stations thereby lightening the work of the stationmasters and their assistants ?

This particular work would necessitate the dispatcher having very detailed knowledge of the layout of the sidings at each intermediate station used in working the trains.

In order that his duties should not be made too difficult and so as not to tax his memory unreasonably, he must be given almost the same facilities and equipment as is provided for the regulator of a large station.

The stations on the dispatcher's diagram are indicated by a single horizontal line whereas on that of the regulator there are as many horizontal lines as there are sidings, and these are grouped into as many groups as there are fans of sidings. Although this does not exactly reproduce the topographical layout of the yards, it provides the regulator with a well defined diagram by means of which he can easily recall to mind the actual layout. Consequently while the dispatcher would have to memorise the layout of each station on his diagram, no such mental effort is required of the regulator. The diagram provided for the dispatcher should thereby have as many horizontal lines as there are sidings set aside for train working purposes.

Beside the object of effecting savings in staff, there are other reasons for which it would be better for the dispatcher to follow up and control the working inside intermediate station limits of passing trains : for example, on lines with heavy traffic at stations inadequately equipped and with only limited capacity, holding or receiving a train in the station on one rather than on another of the sidings can have a very marked influence on the regularity and speed of the trains. The dispatcher could not under such conditions regulate quickly the movement of trains if he were not given the power of using all the minor resources and details of working used in the stations as the dispatcher, under certain circumstances affecting passing trains, may have to act as regulator of the stations along the line.

The innovation may be said to complicate the keeping up of the train working diagram, but nobody will forget that practice soon eliminates any difficulty. Moreover the diagram may be kept up bit by bit.

On double track lines, trains in one direction use at intermediate, as at the main stations, lines quite separate from those used in the opposite direction.

This feature of double track lines enables the telephone circuit to be doubled and to use two dispatchers, one for each direction. These dispatchers follow their trains as though they were operating two different railway lines.

The single dispatcher will consequent-

ly, in the case of double lines, reproduce the movement of the trains more easily if the working of trains in one direction is clearly and definitely distinguished from that in the other.

In order that this may be done instead of showing the stations on the diagram by a single vertical line, two vertical lines parallel and close together should be used, the upper to represent trains marked from the top downwards in the train working diagram (in Italy down trains), the lower train shown in the opposite way (in Italy up trains).

This alteration of the diagram appears to be so unimportant as to be negligible; we think however, that it will be the key, although not appearing to be such, by which to open the way for much more important innovations which it would be difficult to introduce straight away into use because except as regards fashions, new things always encounter violent opposition.

This first step having been taken, the eye of the dispatcher having become accustomed to the concise representation of the train movements over the two principal lines of the station, the opportuneness of adding at some of the stations lines representing the other sidings set aside in the stations themselves almost exclusively to the working (holding sidings, passing loops, etc.) will be readily appreciated.

When the dispatcher has been put in a position to control and direct the working inside the stations dealing with passing trains, the work of the stationmasters and assistants at several intermediate stations will be much reduced.

Theoretically this innovation will enable the hours of duty of assistant-stationmasters at the intermediate stations to be reduced by limiting them to the hours and to the stations having the more intense traffic and by suppressing them at those where they are an unnecessary duplication of work which the dispatcher could do. The system therefore provides a new source of economies which only require a suitable organisation to be explored properly and profitably.

There is no need to look too far afield for a really simple and practical dispatching system suitable for part of our lines, as it can actually be found in our operating regulations where an example is given when dealing with the « disabilitazione » of the stations by concentrating at neighbouring stations the work relative to the movement of trains, of the stations temporarily relieved of the work. Why, by following the same method, should not the stationmaster be removed from each small station which is an unnecessary operating centre ?

Several intermediate secondary stations could be made into simple posts for dealing with the crossing of trains and subsequently grouped together under one of the neighbouring stations at which, owing to its importance or its position, it would be advisable to set up a train working regulator controlling all the stations not equipped in his zone.

As a regulator can direct the whole of the train movements of a large station with several shunting posts, by considering a group of several small stations as a single station with so many posts, the group can be worked by a single station master and the whole of the train working put under a regulator treating it as the interior working of a large station.

The application of this innovation would result in considerable advantages making it possible :

— to reduce the number of operating staff at the small stations;

— to eliminate useless, costly and hindersome duplication of work;

— to improve the running of the trains by confiding the control thereof to specialists provided with all necessary equipment and having nothing else to occupy their attention;

— to use the small stations to a greater extent, these stations at the present time not being used outside the times at which trains call;

— to improve the amount of work produced by the staff at the small secondary stations which, no longer being isolated and abandoned to themselves, would be visited more frequently by the stationmaster in charge of the group and would be under the control exercised by the dispatcher by means of the train diagram of the actual working.

The change requires :

— double track,

— block system,

— interlocking,

— simple and practical regulations,

— selector telephones (Western Electric type already in use on the lines worked under the dispatching system) to link up the dispatchers' offices and the offices of stations not served by the trains, and stations worked in the usual way.

Stations at which there is no train work done would not be handed over, as is done on lines operated with the single controller, to contractors having nothing to do with the working of the trains. These stations would be placed under the regulator of the group to which each station belongs.

The station duties would be covered by employees of the railway solely occupied with administrative duties but who had had operating training so that, in the event of failure, etc., they could act when called upon by the dispatcher.

If the hours of duty of the administrative staff are limited to the periods during which the offices and loading places are open to the public, it will be seen that in those stations at which the overall time they are opened requires several sets of men, staff economies could be made and the service even improved.

Is it possible however for the shunters, pointsmen, signal box staff to do their work regularly and with care when not under the notice of the assistant-stationmaster and that, in stations at which no train work is done, shunting can be done without his assistance ?

This question is quite superfluous because on lines operated by the single controller there are *assuntorie* with a daily movement of wagons exceeding that at many intermediate stations on the main lines and at which shunting is carried out solely by the train staff without any drawbacks and at the same time remarkably quickly.

Furthermore, at almost all stations the absence of the assistant-stationmaster during shunting is neither unusual or novel; it is on the contrary a practical necessity consecrated by custom and increasingly so as the growth of facilities makes it increasingly difficult for the stationmaster, who cannot be everywhere at once, to be present everywhere he should be.

At what station can the stationmaster or his assistant responsible for train working be seen really supervising the shunting ?

Neither in the small stations where he can hardly leave his office to follow so as to regulate the running of the trains on his line, to answer the telegraph and to cover duties outside the train working such as issuing tickets, luggage, goods, etc., nor at medium-sized stations, the lines and goods sidings of which are

often some distance from the passenger buildings, where the stationmaster has to remain to cover the working of the trains, their arrival, and their departure; still less at the large stations at which the general supervision of shunting is left to assistant-stationmasters who have nothing to do with the actual train working on the line.

Let us consider a train just arrived, and follow the way the staff deals with it :

The station staff asks « How many to detach? » The guard replies « Fifteen », to which the station staff adds « And we have twenty for you to pick up ».

To uncouple and couple up again requires about fifteen minutes shunting, but under adverse conditions such as darkness, fog, etc., much more may be taken. In any case, however difficult the shunting may be, the stationmaster or the assistant cannot supervise it personally as he has to remain in his office to give the other stations particulars of the train being dealt with or to take particulars of trains expected, or to decide and announce the order in which trains will run, or to give the signalmen the necessary orders as regards signal working, or finally to be present when trains arrive, depart, or pass through the station, which again makes it necessary for him to be in his office to telephone, telegraph, etc.

In the meantime the shunters go to the sidings with the train, or part of it, where they shunt it. When this is done the train is returned and worked back to the station proper where the shunters report all in order.

If the assistant-stationmaster thinks the shunting has taken too long, he requires explanations and information, and is generally annoyed as he is always held in the end responsible for any delay to the train although he could not be present during the shunting and also lacks the means for considering and discussing effectively the statements and excuses of the staff. After this, when the time of departure arrives or perhaps has passed, the assistant-stationmaster having ascertained from the guard that the train is ready to leave, advises the signal box and when the signals are off, sends the train away.

To sum up, the operating staff are solely occupied with the running of the trains, that is to say the working over the running lines (which could be done much more easily with a single controller) because they can only take part in the station local working occasionally and with little results; this last work is always done by the shunters, pointsmen, and signalmen without the personal intervention of the assistant-stationmaster as it would be done if the verbal orders given by these latter were given by the controller by telephone.

The station staff as a rule, and more particularly the shunters, pointsmen and signal box men, are therefore accustomed to work on their own as, in most small stations, medium stations, and even in those of some importance, they have always had to carry on in the absence of the responsible operating official. For this reason constant improvements are being made in the equipment and plant to ensure the regular development of the service without the operating official having to be away from his office in the booking office building.

Have not the electric and mechanical safety devices, the telephones and the interlocking been increased in number to enable the signal box men and the pointsmen at the points and frames furthest from the station buidling, to carry out their duties during the absence of

the yard master, by the latter being given the equipment needed to supervise and direct them without having to be out on the job ?

As the steady development of the permanent installation, the increase in the speed of the trains, and the greater train density make it essential that the official in control should always have before him the position on the sidings in the station and out on the lines, we can not but take advantage of progress in technical matters, whereby the yardmaster — like a ship's pilot — can follow the increase in traffic and control it without leaving his office.

It is consequently not from any further desire for novelty, but to meet the complex and urgent necessities of the service that the operating control offices at the stations should be reduced and replaced by a very small number of regulating posts. In this way we shall get the dispatchers who, by following the method of the regulator at the large Belgian marshalling yards, will be able to supervise the work of their subordinates, to know to a minute the time required for any train operation, to compare it with the time actually taken and incite and encourage the staff and if need be to discipline them better than if they were present during the work.

The unseen eye of the dispatcher has so great a power of penetration and control that the dispatcher dominates the staff and forces them to work quickly and well; when the dispatching system is not in use, the operating officials have never quite so great authority.

The present need for economy, the post war financial crisis, and road competition force the railway companies to reduce the costs of working. The number of men must be reduced, a desirable step when it means the elimination of really redundant staff, but which loses any benefit and even becomes harmful as soon as the remaining staff have too great responsibility and too much work or results in subsidiary services being neglected; furthermore certain duties, the importance of which is not at first view obvious, are useful in giving the whole organisation an air of order and dignity the large systems cannot afford to abandon.

After having got rid of all redundant staff, before the number of men remaining can be reduced to a minimum all unnecessary duties must be eliminated and the work done by each man increased : because if a man is enabled to do the work of two men without undue exertion one of these may be removed without in any way upsetting the working.

Consequently if it were possible to give every stationmaster the means whereby he alone could do as much as two or three together could accomplish previously with difficulty, why should so appreciable an advantage not be taken up ?

The railways should be capable not only of carrying passengers and goods; they ought always to be ready to meet with the greatest efficiency any unexpected mobilisation for the defence of the country and to guarantee in the event of war, the rapid and perfect transportation of all troups and equipment.

The controller posts proposed to be set up give not only great benefits as regards savings in the cost of operation, but also form in time of peace schools for teaching and keeping in training a selected body of dispatchers thoroughly knowing their duties and always ready to get out of their sections of the lines the greatest possible amount of work, continuously, that can be expected by

rapidly putting into action, by a simple arrangement of circuits, the dispatching system of the Belgian model as on the Porrettana, the only one capable of fully meeting under such circumstances the strategic requirements and the object in view.

The control of train movements in groups of secondary stations that may have been formed would be — in almost all cases — neither hard nor difficult, because on double track lines, even when main lines, the role of the dispatcher of a group of two or three or four (or more) secondary stations will always meet less difficulties than those to be encountered on a single line with much longer sections with many stations and operated by the single controller.

The power of each regulator would be great enough for him to readily overcome the most trying and complicated situations; even long sections of single line would not add very much to his task if the special authorisation to change the passing places by the block system were extended to every case of alteration of passing place, by making the block permissive as the operating regulations provide for if the telegraph and telephones are out of action.

The possibilities and advantages to be got from the setting up of regulating centres can be made more apparent when it is appreciated that at the present time the control of train movements — for the whole 24 hour-period — requires at each station two to six employees (stationmasters, assistant-stationmasters and telegraphists) whereas a group of several stations would be placed under the control of the same station masters or assistant-stationmasters, now become dispatchers, for which only six would be needed.

There is no doubt that even if part of the staff released were used on administrative work — which would make a great improvement — there would be a very large margin of saving for the operating side.

When we consider the very trying daily duties of the stationmasters and their assistants, it may seem absurd to think of improving the service by reducing the numbers of the operating staff : the scientific organisation of labour however produces miracles of this kind.

The regulator has at his disposal complete information relative to the movement, holding and shunting of the trains, to the occupation of the sidings in each station of his groups by a well organised, brief and rapid method such as that of the regulator at the large shunting stations in Belgium; he can therefore reproduce the exact diagram showing the way the trains are running and the position of the empty or occupied sidings of each station. He is therefore at all times aware of the situation at the stations and of the position on the running lines in detail and as a whole.

The result is that the regulator can both more easily and more quickly than the station staff give the order to open the receiving siding for each train, obtain confirmation that the points are properly set, have the signals set to line clear for the incoming trains or to give the signal to outgoing trains, and he can hold at any one of his stations any train which, if allowed to proceed, would upset the working at the next station, using indifferently the facilities at each station even if not staffed and, in addition, to know in advance the composition and the loads of the trains and the number of wagons to pick up at the station; he can give precise orders as regards the shunts to be made and the trains to be worked.

The method would give much greater independence, readily seen too, to the shunters and would make them directly responsible for the delays and irregularities due to negligence, inattention, and carelessness, and would stimulate them to improve their training and their professional knowledge.

The effective work of the regulator and the benefits resulting from his actions would then be much greater than under present conditions (control of train movements by the assistant-stationmaster).

Under the new system, the head guard being more important, his position should therefore be given to men of sufficient education who would be able to carry out safely any particular task which might be laid upon them in the absence of the stationmasters or assistants.

The improvement in professional status of the head guards would make them more careful, quicker in action, and better able to give increased output.

Consequently a method of replacing the old system which breaks the monotony of the work done passively and by habit and which adds value and new responsibilities to the work of each man cannot fail to succeed and to benefit the staff.

The telegraph organisation at present available is a system which no longer meets the needs of the operating department.

Neither the number nor the greater activity, nor the highest ability succeeds under present conditions in avoiding delays and dislocation of the services which always reoccur just as though every traffic department employee did his daily work, difficult and fatiguing as it is, with blameworthy negligence and culpable carelessness instead of with the greatest interest and keenness.

All these defects in the organisation which interfere with regularity in working and demand an excessive number of men, thereby very greatly increasing the operating costs, ought to be eliminated.

[669. 1]

Alloy steels for railroad service.

(From the *Railway Mechanical Engineer*.)

A most informative session on steels was held by the Railroad Division of the American Society of Mechanical Engineers on the afternoon of 5 December 1929, during the annual meeting of that society. The paper discussed was entitled *Alloy Steels in the Railroad Field*, which was presented by Charles McKnight, metallurgist for the International Nickel Company, New York.

A considerable part of the discussion was devoted to the relative merits of carbon and alloy steels, especially as used in locomotive construction. Problems pertaining to handling alloy steels in the average railroad blacksmith shop, and also in welding fractures were discussed by those present. It was evident that both the manufacturers and users were in agreement that the application of alloy steels to locomotives begins where carbon steels cease to render satisfactory service.

Following is an abstract of Mr. Mc Knight's paper together with a summary report of the discussion :

Some confusion has occurred because steels are being sold today under names indicating that they are alloy steels when, as a matter of fact, the content of « alloying element » is slightly above that normal to all steels. An example of this is the so-called « silicon steel » which is used for ship plate and structural shapes. The silicon is actually only a few hundredths of one per cent higher than usual and the term is a misnomer. Such steel could better be called « killed steel » than « silicon steel ». On the other hand, the two elements common to all steels, manganese and silicon have valuable alloying properties, and recently these properties have been taken advantage of to produce a cheap and satisfactory steel.

An alloy steel may be defined in a general way as a steel containing an appreciable percentage of one or more elements (other than iron and carbon) conferring special virtues on the metal. This definition, however, does not tell the whole story. To be worthy of the name, alloy steel must necessarily be of a better quality and made better than a similar straight-carbon steel. Otherwise a large part of the advantage gained by the alloy addition is lost. It is probable that, were it possible to remove the alloy from steel after manufacture, the alloy steel would still be superior to ordinary steel, simply on account of the additional precautions taken.

This quality is one reason for the additional cost of alloy steels. If the price per pound of alloy steel is analyzed, it will be found that the alloy addition alone is not sufficient to account for the excess cost. For example, 3.5 % nickel steel is currently quoted in bar form at 4.15 cents per pound, while carbon-steel bars are a little under 2 cents per pound. The nickel addition alone, even at 35 cents per pound for nickel, accounts for not quite 1.25 cents. Therefore, almost one cent, or little less than the cost of the alloy, goes for the « quality factor ». Although this may seem out of all proportion, it is not unfair for the steel manufacturers to make such a charge, providing the steel is really of good quality.

The designing engineer finds at his hand three types of steel :

Carbon steels. — These steels are used for the vast majority of purposes for very good and economical reasons. There is a tendency, in the view of recent metallurgical developments, rather to belittle carbon steel, but it should be remembered that conscientiously made carbon steel will in most places give more per dollar than any other structural material. The field of locomotion by land, water and air furnishes an outstanding exception to this generalization.

Alloy steels. — Alloy steels are essentially special steels for special purposes. The growth in their use has been and will be rapid, but it is a mistake to use an alloy steel where its use is not justified.

Semi-alloy steels. — This term is really a misnomer as there should be a sharp distinction between alloy steels and carbon steels. At the present time, however, there are steels on the market which have had relatively small extra additions of metalloids ordinarily used in making steel. They are slightly more expensive than carbon steels with slightly better properties. They are a compromise between the two other grades, and it remains to be seen whether they can justify themselves economically.

Forgings of alloy steel.

The locomotive designer in recent years has adopted alloy steel for forgings more generally because of the larger power units, and because the size of forgings cannot be increased indefinitely. Strictly speaking, it is not a new development. In the early days of alloy steel, the railroads were among the first users, but alloy steels got quite an unsavory reputation with them. The reason for this was that it was not then appreciated that mass makes a great difference in the properties of forgings, and that the heat treatment must conform to the size of the piece. It is manifestly ridiculous to compare the 1 1/4-inch rear-axle shaft of an automobile with a 10-inch or 12-inch locomotive driving axle, and yet, in the early days the same steel and the same heat-treatment were used for both with disastrous results in the case of the driving axle.

Fifteen or so years ago, after a temporary lapse, alloy steels again began to be used with intelligently written chemical specifications, and intelligently conceived and controlled heat treatments. While quite a number of alloy-steel forgings are still heat treated by quenching in some liquid medium such as oil or water, it is generally conceded that such drastic treatment, while producing higher strength, is not conducive to the greatest reliability. Strength is, therefore, sacrificed to a slight extent, the cooling medium is air instead of a liquid, and the large forgings of today are much freer from strains and cracks.

The heat treatment in general use today for large railroad forgings in specified by the term « normalize and draw » or « normalize and temper ». In this process the metal after forging but before machining is slowly heated to a predetermined temperature, and is held at that temperature one hour or more for each inch of cross-section. The predetermined temperature is one higher than the so-called « critical point » of the metal, at which the various constituents of the steel merge into an amorphous solid solution. This critical point varies with the carbon and alloy content of the steel. The higher the carbon, the lower the critical point. The alloy having the most marked effect is nickel, which has a tendency to lower it. In the absence of accurate data, 1 600° F. is taken generally as a safe temperature for normalizing. Higher temperatures than this induce excess grain size, and lower ones are not safely above the critical point.

After the steel has remained at this temperature the required time, it is removed from the furnace and is allowed to cool in still air, free from drafts and not exposed to rain, snow, or other chilling agency. When it has cooled so it is no longer red, it is replaced in the furnace and heated to the « drawing » or « tempering » temperature. This is in order to free the metal from stresses set up by cooling, and to put it in the best condition for service from a metallurgical standpoint. The drawing temperature must, of course, be lower than the critical point. It is usually about 1 100 to 1 200° F. and the forgings are again kept at that temperature for one hour or more for each inch of cross-section, after which they are cooled either in the air or furnace. It does not matter greatly which cooling method is used, but probably the air cooling is preferable.

Good heat treatment of alloy-steel forgings is an essential, but again quality is a great factor. No alloy ever made bad steel good. It is necessary, as a metallurgist has aptly said, to begin the manufacture of alloy steel with its pre-natal care, and, as a railroad man even more aptly said, to choose your steel-maker as you would your physician. Quality brings in so many details, such as method of manufacture, rolling vs. pressing, etch-tests, etc., that they can hardly be hinted at, much less discussed in a paper of this length.

The majority of alloy-steel forgings now made conform to one of the following types :

1. Carbon-vanadium steel, normalized and tempered.
2. Nickel steel, normalized and tempered.
3. Chrome-vanadium steel, quenched and tempered.
4. Nickel-chromium steel, quenched and tempered.

The first two air-treated types probably account for more than 75 % of all alloy-steel locomotive forgings, as the latter two are not widely used.

Average of 523 tests on 3.0 % nickel-steel boiler plate.

	Average per cent.	Specified per cent.
Carbon	0.163	0.20 max.
Manganese	0.557	0.40-0.80
Phosphorus . . .	0.021	0.045 max.
Sulphur	0.029	0.045 max.
Silicon	0.203	Not spec.
Nickel	2.960	2.75-3.25

	Average.	Specified.
Ultimate tensile strength	77 880 lb.	70 000 lb. minimum.
Yield point	47 550 lb.	50 % U. T. S.
Elongation in 8 inches	36.33 %	1 600 000 U. T. S. Min. 20 %
Reduction of area	54.15 %	50 %
Impact value, Izod	63.4 foot-pounds.	

As representative of what may be obtained from an alloy-steel forging of large size normalized and tempered, carbon-vanadium steel analyzing :

Carbon.	0.40-0.50 %
Manganese	0.75-0.90 %
Vanadium.	not less than 0.18 %

will give on the average tensile values of :

Ultimate tensile strength . .	90-100 000 lb.
Yield point	60- 70 000 lb.
Elongation in 2 inches . . .	22-28 %
Reduction of area	40-45 %

For comparison, carbon steel with

about the same carbon (0.45-0.50) will give :

Ultimate tensile strength . .	75-85 000 lb.
Yield point	40-50 000 lb.
Elongation in 2 inches . . .	18-25 %
Reduction of area	35-42 %

In the opinion of the author, these are about the maximum results which can be obtained from a normalized steel, no matter what alloy or combination of alloys is used. Yet there is still an uncomfortably large number of failures. In the past there were failures with wrought iron, so steel was adopted; there were failures with steel, so alloy was adopted. Perhaps our reasoning has been wrong, and strength is not the absolute criterion of a good locomotive forging. During the past six years, there has come into prominence and popularity a steel which deliberately sacrifices a little strength to obtain a lot more toughness and shock resistance. The carbon content is much lower than is usual, and nickel is the supporting alloy. Such a steel, normalized and tempered has, in large locomotive forgings, given an average of :

Ultimate tensile strength. . . .	83 535 lb.
Yield point	60 371 lb.
Elongation in 2 inches	31 %
Reduction of area	60 %
Carbon 0.24 %; nickel.	2.58 %

Impact tests are illuminating. Izod impact values on this steel, made on test pieces from large forgings, run 50, 60, 70 foot-pounds, and even higher. This indicates more than double the shock-resisting capacity of the usual higher-carbon alloy steel. Such a steel merits attention.

Alloys used in castings.

The alloys, alone or in combination, most employed in railroad work for steel castings are vanadium with content not less than 0.18 %, manganese 1.00 to 2.00 % and nickel 1.50 to 3.00 %. With a carbon content of from 0.30 to 0.40 %, these alloy steels give minimum physical characteristics of :

Ultimate tensile strength. . . .	80 000 lb.
Yield point	45 000 lb.
Elongation in 2 inches.	25 %
Reduction of area	45 %

Such figures are obtained on large castings, such as frames, after a heat treatment consisting of normalizing and tempering. This treatment is essentially the same as that detailed for forgings. However, due to the difference in the structure of castings as compared with that of rolled or forged steel, it is quite usual to employ a preliminary heat treatment known as a homogenizing treatment. This is carried out at a higher temperature (1 600-2 000° F.), and the castings are air-cooled. By it the original casting structure is more completely broken up. Smaller castings will have somewhat higher properties, and for such castings it is often permissible to use the « quench-and-temper » treatment to obtain even better results, provided the section is not too intricate. In this field, too, interesting results have been obtained by departing from the conventional, and using a low-carbon alloy-steel.

A valuable application of alloy steels for castings was brought out by the chief mechanical engineer of a large railroad. He could obtain low-carbon alloy steel castings at approximately 35 % increase in price over ordinary steel castings. He therefore designed some new power to use alloy-steel castings, cutting down the section on all castings to one-third of the former size, but maintaining a minimum section of 1/4 inch. By these means, the net cost of the castings per locomotive was the same, but the total weight of castings was one-third the previous figure, and the strength was slightly higher. The

saving in weight per locomotive was of the order of 10 000 lb., which could be applied to power-producing purposes.

The only two steels used in any quantity for high-pressure boilers have been manganese from 1.00 to 2.00 %, and nickel, 1.75 to 3.25 %. The vast majority of alloy-steel boilers, in fact practically all, have been made from nickel steel for two reasons. First, boiler plate is *per se* a low-carbon material, and nickel, not being dependent for its alloying qualities on carbon, confers higher properties than any other alloy. Second, while it is possible to obtain as high or higher strength with other alloys, nickel steel develops, to a very high degree, resistance to embrittlement and ageing, and has unusually satisfactory strength at boiler temperatures, a necessity often neglected.

The tensile results obtained with a 3.0 % nickel-steel boiler plate, together with those of carbon-steel plate for comparison, are shown in the tables.

Average of 385 tests on carbon steel boiler plate.

	Average per cent.
Carbon	0.193
Manganese	0.041
Phosphorus	0.022
Sulphur	0.033

	Average.
Ultimate tensile strength	59 200 lb.
Yield point	36 200 lb.
Elongation in 8 inches	28.64 %
Reduction of area	(Not determined)
Impact, Izod	(Not determined)

The mechanical engineer may ask what will happen if even higher pressures are required in the conventional firetube boilers. The answer is that nickel-steel boiler plate can be manufactured with a tensile strength of 100 000 lb. or more, but it is not desirable to do so at present.

Corrosion reduction.

Under the corrosion-resisting type of materials are found such metals as wrought iron and commercially pure iron (Armco), together with low-carbon steels bearing slight percentages of such corrosion inhibitors as copper, molybdenum and nickel. While these materials are not offered as being rustless or corrosion proof, they have proved in long service that under certain corrosive conditions and also exposure to the atmosphere, their life is much longer than that of ordinary steel. Economically they are attractive because, being essentially a steel, their cost is not very much greater than ordinary carbon steel for the same purpose. They are suitable for such purposes as car plates, underframes, firebox sheets, etc.

The second field is a comparatively new development. About ten years ago laboratory experiments indicated that a steel containing chromium around 20 % exhibited certain « stainless » properties. These steels were of fairly high carbon, *i. e.*, about 0.30 %, and were first developed for cutlery and other similar purposes. In this original development it was soon found that their resistance to corrosion was not perfect, and depended to a great extent on the heat treatment which had been given the material and on the finish. The next step was to reduce the carbon as low as possible so that the alloy was really a chrome iron rather than a chrome steel. This material was soft and ductile, and not dependent for corrosion-resistance to the same degree on either heat treatment of finish. It has proved very acceptable. For the next step we are indebted to German metallurgists when they added nickel to the alloy. This resulted in a material which was superior to either of the other two in resistance to corrosion, in appearance, and in workability, and it is now probably the preeminent type of non-corroding steel. It is, of course, sold under a trade name but is

manufactured by several companies in this country.

The economics in the use of this material is that, due to its high price, say 30 cents a pound and higher, it can only be used where the conditions of service are such that the cost is justified either in longer service or in saving cost of replacement of other materials.

It has been used successfully for such purposes as condenser tubes, boiler tubes, superheater parts, etc. To date it is not known that it has been used for firebox sheets, but its use has been contemplated and it would appear that this would be an excellent application on sections where the corrosion conditions are very bad.

Miscellaneous uses of alloy steels.

There is no question that wheels, either steel or iron, can be improved by the addition of alloys, such as manganese, chromium, nickel, and molybdenum. There are today in service many thousand wheels in which manganese is used as an alloying element, and experiments are being undertaken by some of the largest wheel manufacturers to improve their product. It is possible to make a chilled-iron wheel containing alloys which will be much stronger and more wear-resisting than the present chilled wheel but the decision to use these wheels must come from the railroads. As one chilled-wheel manufacturer stated some time ago, their business is to trade a new wheel for one discarded by the railroad, plus 80 cents. Naturally, an alloy wheel cannot be furnished on this basis.

A new development which is being watched with interest by the railroad men is that of « nitriding ». While the process might still be called in the experimental state,and there is no finality as yet, there is considerable promise that this will prove to be a valuable tool in railroad work. By this method a chrome steel with one per cent of aluminium and with or without other elements (1) is machined to the final shape ready to be used, heat-treated and then exposed to an atmosphere of ammonia gas at 1 000° F. or slightly less. After some time at this temperature and exposed to this gas the metal takes on an intensely hard surface. It is possible to procure a surface hardness of around 1 000 Brinell, whereas about the hardest steel obtainable by other methods of heat treating is in the vicinity of 600 Brinell. In addition, since the temperature used is comparatively very low, there is practically no distortion or warping of the parts. The value of such a hard material can be easily appreciated and numerous applications to railroad work can be thought of. For example, one might mention piston rods, crosshead guides, crankpins, valve-motion work, and even axles. One manufacturer is today experimenting with main driving axles where the journal alone is nitrided, and the wheel fit and main body are blanked off so that the ammonia gas does not affect them. The value of this remains to be demonstrated.

Nitriding has been developed to a higher degree in Europe than it has in this country, and recently an opportunity was presented of observing the process as practised by one of the largest companies in Europe. They were nitriding such parts as automobile cylinder blocks, railroad bumpers, valve-motion pins, piston rods, crankpins, pump shafts, gears, and a large variety of other parts, and it was easy to gain the impression that this process was applicable to practically everything.

Discussion.

One of the speakers in discussing the use of alloy steels to secure lighter reciprocating and revolving parts on loco-

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(1) The analysis most used in this country is chromium 0.80-1.30, aluminum 0.60-1.20, molybdenum 0.15-0.25.

motives, pointed out that strength is the primary requirement, but that the steel must have a good degree of toughness and possess the ability to withstand shock and fatigue. With reference to failures of locomotive parts made from alloy steels, he said that the largest percentage was due to mechanical causes such as poor fits, finish or maintenance, and only a few failures were due to inferior quality of the material. Tool marks, sharp fillets and lack of lubrication are the causes of many failures. The same speaker spoke of the various effects of vanadium steel which, he said, are immediately apparent in the improved physical properties and in uniformity of response to heat treatment. The tensile strength is increased and the elastic ratio raised without materially lowering the ductility. Vanadium, he said, imparts thermal stability to steels by hindering the growth of carbide particles, and by restraining the decomposition of the carbides at elevated temperatures. Most of the difficulty encountered in the average railroad blacksmith shop with quenched and tempered forgings, has been due largely to lack of equipment and experience. It was partly to overcome this lack of facilities that the normalizing and annealing treatment of locomotive forgings was developed along with alloy steels.

Another speaker referred to the increased use of springs of chrome-vanadium steel on railroad equipment. He said that carbon-steel springs possessed an elastic limit of about 135 000 lb. per square inch, while chrome-vanadium springs averaged 190 000 lb. The ultimate strength of carbon-steel springs was around 180 000 lb. per square inch, while that of chrome-vanadium approximated 200 000 lb. In addition to these tensile properties, he said, it has been found that the safe commercial stress range for carbon steel is somewhere between 55 000 and 60 000 lb. per square inch. In the case of chrome-vanadium steel it has been found safe to increase this figure from 75 000 lb. to 80 000 lb. per square inch. This speaker claimed that it was possible to increase the flexibility of chrome-vanadium springs and hence obtain easier riding qualities, obtain increased length of life for the spring under certain service conditions, or reduce the weight of the spring. It is possible, he said, to have any combination of these three features.

The question was asked relative to the effect of cutting vanadium or nickel steels with the acetylene torch, and also the use of the acetylene process for welding breaks and fractures. The answer given by several metallurgists present, was that the carbon content in modern locomotive frames ran so low that welding is safe practice. However, heat treatment should be given in all cases.

Several speakers stressed the fact that the user must keep in mind that alloy steels are special steels for special purposes. There is nothing mysterious about alloy steels but care must be used in their handling. Carbon steels have stood up very well in railroad service, have produced good results and are adequate for use in a large number of applications. There are also possibilities, several speakers pointed out, of improving carbon steel.

625. 245 & 656. 225]

Containers for international goods traffic.

Details of a competition for the most efficient design.

Figs. 1 and 2, p. 2126.

(From *Modern Transport* — No. for 8 March 1930.)

On the initiative of Signor Silvio Crespi, President of the Royal Automobile Club of Italy, who first made the proposal during the fifth World Motor Transport Congress, held in Rome in September, 1928, a competition has been organised by the following international bodies to determine the best system of container for international traffic :

International Chamber of Commerce;
Advisory and Technical Committee for Communications and Transit of the League of Nations;
International Railway Union;
Bureau Permanent International des Constructeurs d'Automobiles;
International Association of Recognised Automobile Clubs;
Conseil Central du Tourisme International;
Federation Internationale des Transports Commerciaux Automobiles;
Bureau International de Normalisation de l'Automobile.

A joint committee has been considering the subject for some time, and has decided on the conditions of the competition. It is hardly necessary in the present conditions to stress the importance of having a standard type of container designed to travel on the railway systems of all European and contiguous countries, and suitable for conveyance by road vehicles complying with the regulations of such countries. The matter is probably one in which this country is more closely interested than in any other technical question affecting international land transport, and it should be possible to ensure that the standard container will pass over all British railways. Fortunately, the conditions of the competition take full account of British requirements in this respect, and also lay stress on the important question of the conveyance of containers by sea. The British point of view has been represented on the committee through the International Chamber of Commerce and the International Railway Union, and amongst its members are Major-General R. de Candolle, C. B. (formerly general manager of the Buenos Ayres Great Southern Railway Company), representing the Transit Committee of the League of Nations, as well as Brig.-General Sir H. Osborne Mance, K.B.E., C.B., C.M.G., D.S.O., and Messrs. A. Maynard (assistant chief goods manager, Great Western Railway), and H. W. Phillips (assistant Continental traffic manager, London Midland & Scottish Railway), representing the Interna-

tional Chamber of Commerce. It is probable that in no country has the use of containers made greater progress in recent years than in Great Britain, and yet many of those in traffic are of a type which was introduced some considerable time ago. The competition presents a great opportunity for British brains and ingenuity, for, apart from the value of the prizes, anticipated to amount to a considerable sum, there will be the extensive benefits to be gained from royalties on the design which ultimately secures universal adoption. The principal point to be aimed at is ease of movement and a fortune awaits the designer who can produce a container which can be handled with ease without the assistance of complicated or expensive lifting appliances. The attitude of the British railway companies will necessarily depend upon the efficiency of the design evolved, and if it proves superior in every respect to those now adhered to, there is little doubt that it will de adopted in this country, as well as on the Continent.

Terms of the competition.

A document (numbered 4017, and dated 20 February 1930) was issued under the joint auspices of the various bodies above referred to. The translation of the conditions of the competition, which are given in French, runs as follows :

It is desired to find the most practical solution of the problem of combined goods transport, by rail, sea and road, in order to reduce as far as possible the cost of packing, storing and sorting, and to convey the goods from the point of production to the point of consumption by the most rapid and economical means. The conditions with which the designs must comply and the terms of the competition are set out below :

The following will be allowed to participate in the competition : Firms engaged in the construction of material for railway and motor transport; transport undertakings; syndicated groups of these industries; technical schools, commercial high schools; public organisations (organisations d'intérêt public) dealing with traffic and transport questions.

The competition will be held at the offices of the International Chamber of Commerce, and will be governed by French Law. All communications must be addressed to the Comité International du Concours Container, Chambre de Commerce Internationale, 38, Cours Albert I[er], Paris.

Conditions.

1. — The containers (cadres) must be of the open and of the closed types. In each of these types the competitors must elaborate three containers of different volume. The external dimensions of these three containers measured over-all (comprising all projections) must be as follows :

First category.	Second and third categories.
Length : 3.95 m. (12 ft. 11 1/2 in.) *Width :* 2.15 m. (7 ft. 0 5/8 in.)	At the competitor's option, provided, however, that they (the dimensions) are sub-multiples of the first figure.

Height :
2.20 m. (7 ft. 2 5/8 in.) for closed containers.
1.10 m. (3 ft. 7 1/4 in.) for open containers.

Each of these containers must be made in such a manner that it should be capable of carrying a load of 5 tons after deducting the tare. Competitors must endeavour to design the containers with the lowest tare possible, while at the same time ensuring that the parts composing them are capable of resisting the pressure of the maximum load. All these containers must be capable of being transported by motor lorry, by open goods wagon (standard and narrow gauges) and by steamship.

2. — The open type containers are destined for the transport of raw materials or semi-manufactured materials which it is not necessary to protect from bad weather; on the other hand, the closed type must be construct-

ed in such a way as to protect the goods transported against damage caused, directly or indirectly, by bad weather and notably by internal condensation or by the humidity of truck or van boards. However, they must be capable of being ventilated whenever this is necessary.

Competitors must give precise details of construction concerning the closing and opening of the container, so that these manipulations may be executed rapidly in loading and unloading the goods.

If there are to be vertical hinged doors, the bottom part of these doors must be at least 50 cm. above the level on which the frame is to rest, so that the leaves (of the door) may be opened above the sides of open railway wagons or motor lorries. Additionally, the section of the wall of the container below the doors must be capable of being opened out over an angle of 180°.

All containers, both open and closed, must be capable of being fitted together, placed on top of one another, and placed side by side.

There must be no interior projections, but it must be made possible to stow the goods along the containers by means of rings fitting into grooves at suitable heights or by means of some other device.

3. — The containers must be very solid, as they may be subjected to many shocks and to several risks of damage, resulting particularly from hoisting chain shocks and deformation of the walls during hoisting. Competitors must bear in mind that these containers, especially when on ships, may also be stacked on top of each other — three of the first category may be so stacked — but the necessity for making the tare weight as low as possible must not be overlooked.

4. — Competitors must submit proposals concerning containers which are not capable of being taken to pieces. They are, however, at liberty to submit separate proposals concerning containers which can be dismantled for transport when empty. In the latter case competitors must study the manner of grouping the different parts, so that it should be impossible for them to get separated.

5. — In elaborating their proposals, competitors must conform to the customs conditions based, in the case of trucks, on the international regulations. (See chapter 2 of the Final Protocol of the Third International Conference held at Berne on 18 May 1907.)

6. — The containers must be fitted with devices necessary to raise them by means of cranes, hoists, and other lifting appliances. They must also be fitted with devices necessary to enable them to be moved by sliding (by means of ramps, inclined planes, etc.). On the other hand, it is advisable to avoid, as far as possible, all detachable apparatus which it would be necessary to remove whan sliding or rolling the containers. Competitors must give details of the operations necessary to load the container on to a truck or van from the ground and to unload it from truck or van, and also to transfer it from truck to van, and *vice-versa*.

7. — Competitors must indicate the method to be adopted in lashing the container on a truck or van. If the container comprises for that purpose special apparatus, the inventor must also submit the designs of such apparatus and indicate the manner of manipulation. The lashing devices must in all cases be such as not to cause damage to the truck or van, and must be capable of being fixed easily and rapidly to existing trucks.

8. — For each type of container for which designs are submitted, competitors must give precise details of the nature of the materials to be employed in its construction, the tare provided for, and the estimated manufacturing cost of the container, of the attaching devices and of the devices which may be suggested to facilitate loading and unloading. Prices must be stated in dollars.

9. — In judging the relative value of the designs, the jury will consider those in which competitors have ensured :

a) Lowest weight;

b) Greatest economy in manufacturing cost, bearing in mind any licence fees;

c) Greatest economy in maintenance cost and maximum durability;

d) Easiest, most rapid and cheapest hand ling of container;

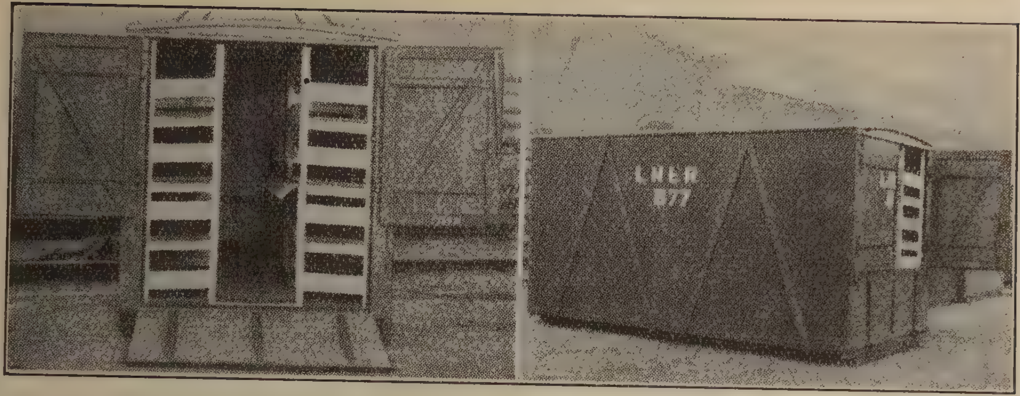

Fig. 1. — Two illustrations of a B type (covered) container, as used on British railways. In this instance the container is fitted with shelves for conveying bottled sweets and confectionery.

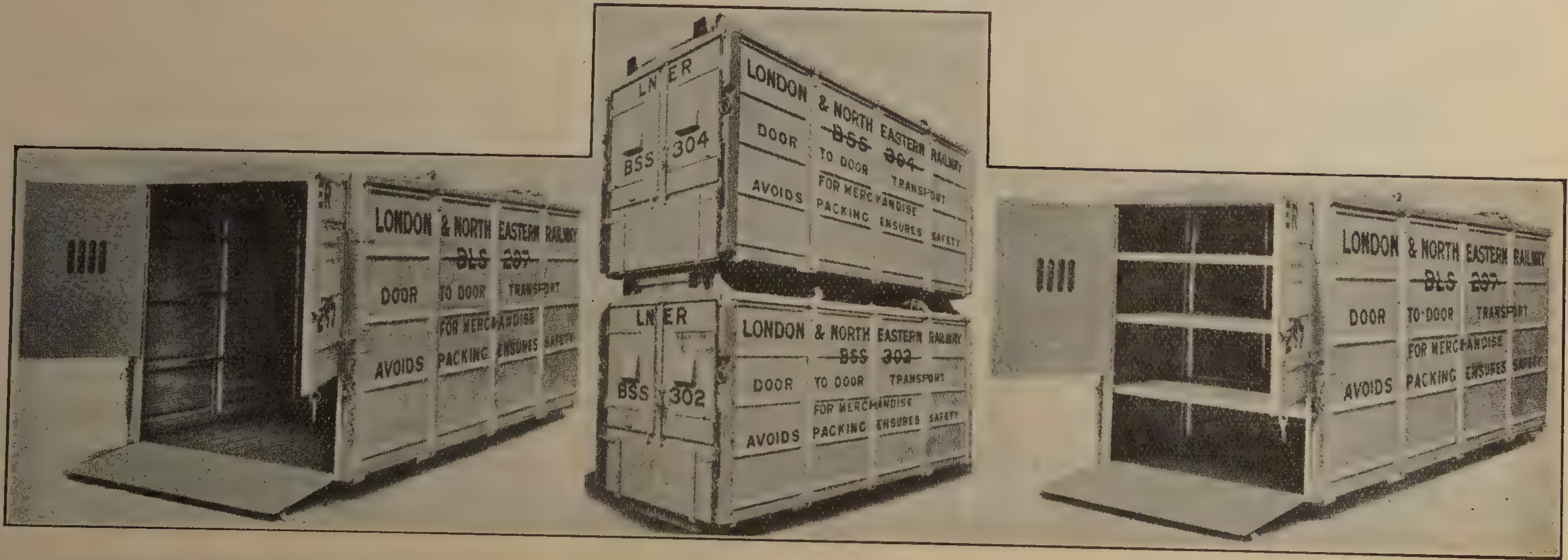

Fig. 2. — Types of steel containers built by the Metropolitan-Cammell Carriage, Wagon and Finance Co. Limited. Those in the centre

e) Minimum requirements as regards manner of fixing the container on railway wagons and motor lorries;

f) Best locking devices.

10. — The competition will consist of two parts. For the first part competitors must submit their tenders to the International Chamber of Commerce before 10 September 1930, accompanied by :

a) Drawings of the complete container at a scale of not less than 1/10;

b) Detail drawings, at a scale of not less than 1/5, as regards principal characteristics of construction and as regards devices for securing the container on rail and road vehicles;

c) Calculations concerning sections and parts subjected to considerable strain, especially the lifting parts;

d) If such should arise, indication of patents covering part or all of the devices offered, as well as the amount of royalties which would be demanded for the exploitation of each of those patents.

The designs and enclosures must be explained in French, but they may be accompanied by a copy written in the native language of the competitor. The jury will then effect a selection. The designs will be retained for the second part of the competition.

For the second part competitors must make arrangements for the construction of their apparatus, which will be subjected to such tests as the jury may consider necessary. The jury will be entitled to ask several competitors to come to an understanding and submit one and the same apparatus embodying the devices which would have been retained separately in their individual schemes.

Should a competitor refuse to conform to the instructions contained in the preceding paragraph, the jury will be entitled to have the apparatus constructed themselves; and its cost will be deducted from the prize, which would eventually be distributed among the dissenting competitors.

11. — The jury will have full freedom to grant, within the limits of the amount placed at their disposal for the purpose, such prizes as they consider justified by reason of the value of the new designs submitted to them. This amount therefore constitutes a maximum, which the jury may not entirely exhaust if they consider it inadvisable to do so.

12. — The winning apparatus will be exhibited.

Increasing use in Great Britain.

Door-to-door transit of goods by railway-owned containers has passed the experimental stage in Great Britain, and a gratifying measure of success has been achieved. The traders have expressed satisfaction with the scheme, which gives many of the advantages of a private siding, minimises the risk of damage and pilferage, saves handling, and effects considerable economy in packing, in the cost of packing materials, and in the carriage thereof. On their part, the railway companies have seen a return for their outlay in a steady but appreciable return to rail of traffic which ordinary conveyance had failed to retain. As a general rule, the railway companies add a small percentage charge to the rates for traffic so conveyed, but as the addition is small, being often as low as 5 %, and usually representing less than the saving effected on packing costs, the supplement is considered a reasonable business arrangement. Container-conveyed goods are charged at net weight only, nothing being added for the weight of the receptacle.

Dimensions of British containers.

Details relating to the containers were given in *Modern Transport* when the scheme was introduced in December 1927. The containers are stoutly built of timber; three types — A, B and D — are in general service. « A » is a covered type weighing 17 cwt. 0 qr. 14 lb., with inside measurements of approximately 7 feet by 6 feet by 6 ft. 7 ft. 2 in., and capable of carrying 2 1/2 tons. Type « B » is also a covered container, of

1 ton 6 cwt. 1 qr. tare weight, with inside measurements of 13 ft. 3 5/8 in. by 5 ft. 9 in. by 6 ft. 2 in., and constructed to carry 4 tons; whilst type « D » is an open receptacle weighing 1 ton 3 cwt. 1 qr., measuring 13 ft. 3 in. by 6 ft. by 3 ft. inside and having a carrying capacity of 4 tons. A further open type, « C », measuring 7 ft. by 6 ft., with sides 3 ft. high, is in use on certain lines. Experiments are being made with other containers of similar or slightly larger dimensions but lighter construction. The all-metal type is finding increasing favour, and examples of it are illustrated in figure 2. The loads obtained naturally vary according to the class of goods conveyed; a full load of such traffic as toffee will weigh fully 4 tons, while gramophones barely yield anything over the minimum weight, which is 1 ton per container. There are few commodities which do not lend themselves to container conveyance, but where ordinary containers are not entirely suitable, *e. g.*, as for bottled sweets not in cases or crates, shelves can be fitted to ensure safety during transit.

Working.

The working of the containers at the forwarding and receiving points depends on the position of the trader's premises and the lifting facilities available. The empty container is generally carted to the sender's premises and loaded by him while it is on the dray. If the period so occupied is likely to be short, the carter and his team stand by until loading is completed, and this is invariably the case if the trader's premises are some distance from the station. In other cases, the dray, or trailer, is left, with the container upon it, the horses (or motor) calling back for the load when ready. At the destination point the same procedure takes place, but in the reverse order. A recent extension of container traffic has been made in connection with goods to or from the Continent, door-to-door transit being given without breaking bulk, in spite of the intermediate sea passage, and a fair volume of traffic, both export and import, is already passing in this manner, typical items including steel window frames to Mechlin, trees and shrubs from Holland, and baths from Germany. The initial stock of containers was built to meet a demand which it was necessarily difficult to estimate, and, with the existing comparatively small number of each type, twenty-four hours' notice has often been required from the sender, but this requirement will be obviated as additional containers are put into traffic. The field for their use is an extensive one, and, with increasing experience and further experiment to determine the most suitable methods of design and construction, the container system should become a normal method of railway transport for the classes of goods for which it is principally designed.

[385.3 (.73) & 656.25 (0 (.73)]

Interstate Commerce Commission reports on signaling.

(Railway Signaling.)

The annual report of the Interstate Commerce Commission, issued on 5 December 1929, included a section concerning signals and train control, an abstract of which follows :

All installations of automatic train-control devices required by our orders of 13 June 1922 and 14 January 1924 (1), have been completed, and in accordance with further provision of the orders that each of the installations made pursuant thereto shall, when completed, be subject to inspection by and approval of the Commission or any division thereof to which the matter may be referred, inspections and tests have been made by our engineers of all completed installations, 77 of which have been tentatively approved with exceptions and recommendations in respect to certain features which required further consideration, and seven of these installations have received final approval, the carriers having taken measures to meet certain requirements and to correct certain conditions pointed out as a result of the initial inspections.

Installations for the improvement of safety and protection on the railways in the United States, year ended 31 December, 1928.

Cl ss I steam roads of the United States.

Item.	Units (2)				Gross expenditures (3). (Dollars.)
	Item.	New installations.	Improvements to old.	Total.	
1. Automatic train-control and cab-signal devices:					
a) Roadway	Miles of track.	1 649.25	1 197.16	2 846.41	1 439 251.88
b) Locomotives equipped	Number.	692	308	1 000	1 581 401.76
2. Block signals:					
a) Automatic	Miles.	3 304.93	2 163.41	5 468.34	9 913 483 17
b) Manual, controlled manual and staff.	do.	694.70	18.10	712.80	177 312 39
c) Protection for operation on reverse main.	do.	193.10	4.25	197.35	437 206 68
3. Interlocking plants:					
a) Manual and power	Number.	79	325	404	5 101 527.15
b) Automatic	do.	35	20	55	399 483.61
4. Protection or elimination of highway grade crossings:					
a) Separation of grades	do.	430	106	536	26 294 151.88
b) Abandonment or removal.	do.	407	54	461	716 477.26
c) Automatic warning devices, gates, signals, and signs.	Crossings protected.	1 652	1 024	2 676	2 437 707.97
d) Other improvements at crossings.	...	...	...	...	1 361 079.18

(1) See *Bulletin of the Railway Congress*, July 1922, p. 980 and July-August 1924. p. 588.
(2) Installations which were completed and put into service during the year 1928
(3) Gross expenditures made on the classes of installations or projects indicated, whether completed or not during the year.

Item.	Units (1) Item.	New installations.	Improvements to old.	Total.	Gross expenditures (2). (Dollars.)
5. Elimination of railway crossings (railway with railway :					
a) Separation of grade . . .	Number.	11	...	11	754 654.78
b) Other removals	do.	36	1	37	25 697.80
6. Remote power switches. . .	do.	100	1	101	552 133.28
7. Spring switches	do.	112	3	115	61 980.38
8. Derails, other than in interlocking plants.	do.	1 495	195	1 690	106 143.89
9. Central control dispatchers' systems.	Number installed	4	...	4	153 176.28
	Miles of road	37.70	...	37.70	
10. Additional main track (excluding cost of heavier rail and passing track).	Miles.	327.91	1.02	328.93	17 306 808.53
11. Passing tracks:					
a) Additional	Number of tracks installed.	124	...	124	2 280 319.02
	Total feet.	488 590	...	488 590	
b) Extending length	Number of tracks extended.	407	208	615	4 181 577.00
	Total feet.	671 054	368 245	1 039 299	
12. Improvements in switching yards:					
a) Switch leads independent of main track.	Feet.	502 650	289 126	791 776	3 605 621.92
b) Hump yard car retarders.	Number of retarders.	118	6	124	1 011 356.65
13. Reduction of grades or curvature (other than at highway crossings).	Number of projects.	42	39	81	14 872 969.53
	Miles of road.	49.29	101.35	150.64	
14. Replacing of wooden bridges and trestles with permanent, concrete or steel structures.	Number.	1 171	1 566	2 737	...
	Feet.	97 310	150 519	247 829	10 764 955.72
15. Heavier rail	Tons	644 956	862 897	1 507 853	56 990 037.32
16. Steel passenger-train cars . .	Number.	1 374	1 588	2 962	32 377 329.23
Total	...	...	...	...	194 903 954.26

(1) Installations which were completed and put into service during the year 1928.
(2) Gross expenditures made on the classes of installations or projects indicated, whether completed or not during the year.

Additional items chargeable to operating expenses were reported as follows :

Crossings and signs.	$13 069 234
Signals and interlockers . .	32 249 359
Signal and interlocker operation	25 931 924
Crossing protection	20 620 049
Expenses of safety organizations.	1 337 820
Total. . .	$93 208 386

Three installations on which reports have not been issued may require reinspection before tentative approval can be given.

Under our orders a total of 8 387.7 miles of road, 15 187.2 miles of track and 7 929 locomotives have been equipped with automatic train-stop or train-control devices. In addition, a number of carriers have voluntarily equipped beyond the requirements of our orders 3 065.7 miles of road, 5 052.1 miles of track and 975 locomotives, the installations now in service comprising a total of 11 453.4 miles of road, 20 239.3 miles of track, and 8 904 locomotives. During the year there was an increase of 240.1 miles of road, 535.8 miles of track and 408 locomotives equipped with automatic train-stop or train-control devices. Information regarding these installations is shown in greater detail in the report of our Bureau of Safety, which is published separately.

As a result of an investigation and hearings held on our own motion during February and April 1928, in the matter of automatic train-control devices, we issued a report under date of 26 November 1928, stating that we had concluded not to require by order at that time further installation of train-stop or train-control devices; the carriers, however, were expected to be diligent in their efforts to provide adequate protection against accidents due to grade crossings, derailments, collisions in territory not protected by block signals, failure of wooden bridges and trestles, and the use of wooden passenger-train cars, which have been repeatedly mentioned in our recommendations to the Congress. We also expressly stated that this action in no way relieved the carriers from the responsibility which rests on them to provide additional protection where needed in territory now equipped with block signals.

Information concerning improvements and expenditures in the general field of safety by Class I railroads has been obtained for the calendar year 1928, which, as shown in the accompanying table, indicates the extent and nature of projects of this character which were in progress prior to and at the time of issuance of our report of 26 November 1928, referred to above. Some of the items in this statement, such as additional main track, passing tracks, improvements in switching yards, reduction of grades and curvature and heavier rail, can scarcely be regarded primarily as safety matters, although along with improved operating conditions which are brought about by these expenditures it follows that there is an increase in safety. Partial information has been secured concerning installations of safety devices of some of the classes listed in the table which were undertaken or in progress during the first nine months of the calendar year 1929 : these reports are summarized as follows :

Additions to automatic train control installations :

Boston & Albany Railroad : 9.25 miles double track, Brookline Junction, Mass., to Riverside.

Boston & Maine Railroad : 5 miles double track, Hoosac Tunnel.

Central Railroad of New Jersey : 11.5 miles

single track, Matawan, N. J., to Atlantic Highlands.

Pennsylvania Railroad : 32 miles double track, Newark, Ohio to Columbus, 210.9 miles of road, 719.2 miles of track, cab signals, Manhattan Transfer, N. J., to Washington, D. C.

Richmond, Fredericksburg & Potomac Railroad : 9 miles double track, NA tower to Richmond, Va., and AF tower to Potomac River Bridge.

Southern Pacific : 30 miles double track, Emigrant Gap, Cal., to Andover.

Automatic block signals : Approximately 4 200 miles of road.

Centralized traffic control systems: 9 roads, approximately 250 miles of road.

Interlocking plants and remotely controlled switches and signals : 95 plants, 2 467 working levers.

At the hearings before us in *Automatic Train Control Devices,* above referred to, it was stated by representatives of the Pennsylvania that it is planned to equip the line from North Philadelphia to Manhattan Transfer, and from time to time other portions of its main line, with a system of visible and audible cab signals without automatic train-stop devices. Concerning this matter we said in our report of 26 November 1928 :

Page 108. Cab signals are without doubt an important development in the art of signalling. They place the signal indication immediately in front of the engineman where it can not be obscured by snow, fog, smoke or other obstructions and where a combination of visible and audible indication is used it is without doubt a valuable addition to the signal system.

Page 201. The development of cab signals of the type now in use on the Pennsylvania appears to be an important forward step in the art of signalling and worthy of special attention. If the claims of that carrier are not overstated, such signals will be particularly valuable on mountain grades, where it has been vigorously contended that the use of any device which under any circumstances might take the control of the train away from the engineman would be a source of danger and not a safety device. The Pennsylvania will be expected to proceed with the further development of this device and to conduct suitable tests on its mountain division between Altoona and Pittsburgh, Pa., with a view to equipping that division if satisfactory results are obtained.

As a result of investigation of an accident which occurred near Short Lane, Md., on the line of the Pennsylvania between Baltimore and Philadelphia, our Bureau of safety reported that :

The accident here under investigation occurred in a dense fog when wayside signal indications were visible only for very short distances, and fogs of this character are frequently encountered in this locality. In view of the character and density of traffic on this line it is believed that the Pennsylvania should give immediate consideration to the question of extending their cab signal system or installing automatic train control on the main line of the Maryland Division for the purpose of providing additional protection against accidents of this character.

Following the issuance of this report, the Board of directors of the Pennsylvania authorized the installation of cab signals on the Maryland and Baltimore divisions, between Philadelphia, and Washington, an appropriation of $704 830 being made for this purpose. An appropriation of $1 489 193 to cover the cost of the cab-signal installation on the New York division, between Philadelphia and Manhattan Transfer, including 79 miles of road and 326.6 miles of track, had previously been authorized, the total authorized expenditure for cab-signal equipment on this line being $3 194 023.

Prior to 25 September 1929, the equip-

ment of the 217 steam locomotives which are operated between Philadelphia and Manhattan Transfer had been completed. Work on the roadway equipment between Manhattan Transfer and Trenton was well under way and it was expected that this portion of the installation would soon be ready to be placed in service. Between Trenton and Philadelphia, because of an electrification project to provide for the operation of multiple-unit cars which is now in progress and which includes extensive changes in the signal system, it was expected that the cab-signal installation would be ready for service about 1 July 1930.

The territory between Philadelphia and Washington includes 131.9 miles of road and 392.6 miles of track and the locomotive equipment in service in this territory consists of 166 steam locomotives, 1 electric locomotive, and 287 multiple-unit cars. Prior to 25 September 1929, the installation of cab-signal equipment had been completed on 77 of the locomotives in this territory and additional locomotives were being equipped at the rate of about 28 per month. One multiple-unit car had been equipped and arrangements were being made to conduct tests, the results of which would determine some questions not then definitely decided in connection with the equipment to be installed on multiple-unit cars in service between Philadelphia and Wilmington. The roadways work on the installation between Philadelphia and Wilmington had been practically completed; between Wilmington and Washington it was under way, most of the work being carried on between Perryville and Baltimore, particularly on those parts of the road where fogs are common, and it was expected that the cab-signal installation in this territory would be ready to be placed in service about 1 January 1930.

Some important developments in the field of railway signalling which are now in use or being installed on a number of railways are :

Remote control of power operated switches and signals, by means of which operators at stations or interlocking plants control outlying switches and signals and thereby avoid the stopping of trains moving to or from diverging tracks.

Centralized control of traffic, by means of which traffic over a section of line is controlled by a dispatcher at a central point. This system includes remote control of switches and signals; it provides for the operation of trains by signal indication, without written train orders, and it also provides means whereby the meeting and passing of trains, and trains taking siding, can be directed and controlled without stops or with a reduced number of stops.

Protection of crossings by automatic signals, by means of which train movements over crossings of railroads at grade where there are few or no switching movements are safeguarded without requiring more elaborate and expensive interlocking plants.

Light signals are coming into general use in installations of the automatic block system. On 1 January 1929, nearly 15 000 miles of road, approximately 25 % of the total automatic block signal mileage of the country, were equipped with light signals.

Block-signal statistics.

The statistical analysis of the returns submitted by the carriers covering block-signal statistics shows that on 1 January 1929, there were 114 388.4 and 148 326.8 miles of road and track, respectively, operated by the block system. Of these totals 56 488.6 miles of road and 85 890.8 miles of track were under automatic block and 57 849.8 miles of road and 62 436 miles of track were operated

under non-automatic signals. Comparing these figures with the corresponding figures shown in the compilation of 1 January 1928, there was an increase of 2 872.1 miles of road and 3 826 miles of track operated by the automatic block system; and a decrease of 1 526.1 miles of road and 2 025.8 miles of track operated by non-automatic block systems. There was a net increase during the year in the mileage operated under block-signal protection of 1 346 miles of road and 1 800.2 miles of track.

[313 : 625 .143.3]

Statistics of rail breakages during the year 1928.

(*Continued*).

We continue hereafter the publication of the statistics of rail breakages which occurred during the year 1928, the first part of which appeared in the number for October last, pages 2043 to 2093.

For the sake of simplification and unless stated otherwise :

Light rails applies to rails of a weight less than 85 lb. per yard (42.5 kgr. per metre).

Medium rails, to rails weighing 85 to 105 lb. per yard (42.5 to 52.5 kgr. per metre).

Heavy rails, to those weighing 106 lb. per yard (53 kgr. per metre) or over.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load.
1	2	3	4	5	6	7		9	10	11	12	13	14	15	16	17
GREAT BRITAIN AND NORTH OF IRELAND. Great Western Railway.																English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	16
Medium rails	1	...	...	1	...	...	3	...	...	6	...	...	6	...	...	22.5
Total. . . .	1	...	...	1	...	...	3	...	...	6	...	...	7	...	...	...

Number of train-miles: 64 154 870.
Total number of fractures: 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train miles: 1.76.

PARTICULARS OF THE FRACTURES.

A. — Percentage of breakages in respective portions of rails covered by and clear of the fishplates:

Covered by fishplates: 9 = 50 °/..
Clear of fishplates: 9 = 50 °/..

B. — Percentage of fractures according to the appearance of the fracture:

a) Fresh and clean through the whole of the rail section: 5 = 27.77 °/.

1. With silvery oval mark: ...
2. Without silvery oval mark: 5 = 27.77 %

b) Fractures, part of which is old and much rusted, extending to the outer face of the foot or head of the rail:

1. Rusted part in the foot: 2 = 11.11 °/..
2. Rusted part in the head: 8 = 44.44 °/..

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail: 3 = 16.66 °/..

d) Number of pieces into which the rail was broken:
2 pieces 16 = 88.88 °/.. 3 pieces: 2 = 11.11 °/..

Note. — Compiled on full section rails only. A fracture is considered to be a complete break through the rail, or a complete interruption of the top flange. Wing rails of crossings and stock rails of points are not included.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London Midland and Scottish Railway.		Miles.			Miles.			Miles.			Miles.			Miles,		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	2	1 105	1.13	20.9
Medium rails	7	2 135	2.05	7	1 869	2.34	5	1 229	2 54	16	1 986	5.04	21	5 033	2.60	20.9
Total. . .	7	2 135	2.05	7	1 869	2.34	5	1 229	2.54	16	1 986	5.04	23	6 138	2.34	...

Number of train-miles : 150 907 173.
Total number of fractures : 58.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.4.

Running lines reduced to single track : 13 357 miles taken from statistical return — Sidings not included.
The total of fractures includes those on goods lines.

PARTICULARS OF THE FRACTURES.

A. — Percentage of breakages in respective portions of the rails covered by and clear of fishplates.
Clear of fishplates : 42=72.4 °/.. — Covered by fishplates : 16=27.6 °/..

B. — Percentage of fractures according to the appearance of the fracture.
a) Fresh and clean fracture through the whole of the rail section : 26 = 44.8 °/..;
b) Fractures part of which is old and much rusted extending to the outer face of the foot or head of the rail.
1. Rusted part in the foot : 7 = 12.1 °/.. ;
2. Rusted part in the head : 6 = 10.3 °/...

One case both foot and head.
c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : 15 = 25.8 °/...
d) The number of pieces into which the rail is broken
2 pieces : 42 = 72.4 °/..
3 — 9 = 15.5 °/..
4 — 7 = 12.1 °/..

The above is compiled on full section rails only. A fracture is considered to be an entire separation from top to bottom (or a complete interruption of the top flange).
Cranked or bent rails are not included when broken at the bend. Wing rails of crossings are included when the fracture is not at the bend.
Side or stock rails of points are included.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London and North Eastern Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	45.29	...	...	46.50	...	...	58.96	...	...	140.85	...	3	1 624.51	1.15	20
Medium rails	7	1 707.63	2.56	3	1 182.41	1 58	4	1 315 82	1.90	6	1 504.30	2.49	14	2 843.29	3.08	22.5
Total. . .	7	1 752.92	2.49	3	1 228.91	1.52	4	1 374 78	1.82	6	1 645.15	2.28	17	4 467.80	2.38	...

(*) In running lines.

Number of train-miles : 106 422 934.
Total number of fractures : 37.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.17.

Rails are broken when : *a)* completely severed from top to bottom ; *b)* also when a piece of the head is broken away leaving a gap in the running surface. — *Broken rails in sidings not included.*

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Southern Railway.		Miles.			Miles.			Miles.			Miles:			Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	14	237.1	37.0	...
Medium rails	2	781.7	1.6	4	900.2	2.8	7	263.1	16.6	7	792.8	5.5	5	1 074.5	2.9	20.65
Total. . .	2	781.7	1.6	4	900.2	2.8	7	263.1	16.6	7	792.8	5.5	19	1 311 6	9.0	...

Number of train-miles : 55 866 427.
Total number of fractures : 39.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4.36.

A. — Percentage of breakages in the respective portions of the rails covered by, and clear of, the fishplates:

Breakages covered by fishplates = 34 = 87.18 %.
Breakages clear of fishplates = 5 = 12.82 %.

B. — Number of fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section :

1. With silvery oval mark : Nil
2. Without silvery oval mark : 22

b) Fractures, part of which is old and much rusted, extending to the outer face of the foot or head of the rail :

1. When the rusted part is in the foot : 1
2. When the rusted part is in the head : 8

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : Nil

Breakages not classified in types *a*, *b* and *c* : 8

Total : 39

d) The number of pieces into which the rail is broken :
Two pieces : 29. — Three pieces : 9. — Four pieces : 1
Total : 39

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cheshire Lines Committee.					Miles.											
Medium rails : (95 lb. per yard).	...	...	...	1	192.25	3.21	...	...	...	...	...	...	...	...	...	...
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Northern Railway (Ireland). (*)														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	3	151.743	12.35	18

(*) In passenger lines.

Number of train-miles : 3 991 187.

Total number of fractures : 3.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4.69.

A. — Percentage of breakages in the respective portions of the rails :

1. Covered by the fishplates . . . . 33.33 %
2. Clear of the fishplates . . . . 66.67 %

B. — Percentage according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section : Nil.

1. With silvery oval mark . . . . } Nil.
2. Without silvery oval mark . . . . }

b Fractures, part of which is old and much rusted, extending to the outer face of the foot or head of the rails :

1. Rusted part in the foot . . . . 100 %
2. Rusted part in the head . . . . Nil.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail . . . . Nil.

d) Number of pieces into which the rail is broken : 2 rails into 2 pieces, 1 rail into 3 pieces.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Metropolitan Railway (London.)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Medium rails	1	25.8)	...	...	15.56	...	1	17.80	...	...	4.70	...	...	10.68	...	19.5

Number of train-miles : 5 230 138. Total number of fractures : 2.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Underground Electric Railways Company of London (District Railway and Tube Railways).		Miles.			Miles.			Miles.			Miles.					English tons.
Medium rails :																Dist. Ry. : 11.25 Tube Rys : 11.50
District Railway	1	12.5	50.00	...	20.0	...	...	12.0	...	...	10.0	...	...	...	...	
Tube Railways	...	51.0	...	...	10.0	...	...	6.00	...	4 (1)	5.C	500	(1)(2) 3	32.7	57.33	

Number of train-miles : District Railway : 4 600 000.
— — Tube Railways : 13 000 000.
Total number of fractures ; District Railway : 2.
— — Tube Railways : 7.

Numbe of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles :
District Railway . 1.36.
Tube Railways : 3.37.

County Donegal Railways Joint Committee. — No case of fractured rails in 1928.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Central and Midland Joint Committee. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Medium rails	...	9.61	...	1	3.69	161.81	...	1.48	...	...	6.21	...	...	10.60	...	20

(*) In running lines. London & North Eastern Railway Co's maintenance.

Number of train-miles : 173 852.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 35.95

Rails are broken when : a) completely severed from top to bottom;

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
London Midland and Scottish Railway (Northern Counties Committee), Ireland.											Miles.			Miles.		English tons.
Light rails :	...	...	...	...	...	...	...	...	...	1	30	21	7	217.9	20	17.5

Number of train-miles : 1 626 184.
Total number of fractures : 8.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 31.

A. — Percentage of breakages in the portion of the rails :
Covered by the fishplates : 50 %.
Clear of the fishplates 50 %.

B. — Percentage of fractures according to the appearance of the fracture :

a) Fresh and clean fracture through the whole of the rail section :
Without silvery oval mark : 50 %

b) Fractures, part of which is old and much rusted, extending to the outer face of the foot or head of the rail :

1º Rusted part in the foot : 12 1/2 %.

c) Fractures with much rusted portions not extending to the outer face of the foot or head of the rail : 37 1/2 %.

d) Number of pieces into which the rail is broken : 66.7 % in 2 pieces, and 33.3 % in 3 pieces.

Midland and Great Northern Railways Joint Committee. — No fractured rails in 1928.

INDIA, DOMINIONS, PROTECTORATES AND COLONIES

—

AFRICA

Gold Coast Government Railways. — No cases of broken rails in 1928.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kenya and Uganda Railways and Harbours.		Miles.												Miles.		English tons.
Light rails	1	130	...	...	...	...	...	...	...	...	...	...	12	700	...	15

Number of train-miles : 4 302 048.
Total number of fractures : 13.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	SECTION OF LINE.	NUMBER OF FRACTURES AND PARTICULARS OF TR													
		AGE OF RAILS :													
		Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 y	
		Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			Miles.												
Beira and Mashonaland and Rhodesia Railways.															
	Beira-Villa Machado. . .	...	...		...	...	...	...	...	...	...	...		...	61
	Villa Machado-Umtali . .	1	59		...	...	...	...	...	...	...	...		2	84 1/4
	Umtali-Salisbury.	...	70 3/4		...	...	...	...	...	...	...	...		1	99 1/4
	Salisbury-Bulawayo . . .	...	...		...	...	...	...	...	...	...	...		16	295 3/4
	Bulawayo-Livingstone. .	...	12 1/2		...	80	...	...	...	...	...	...		9	194 1/4
	Livingstone-Broken-Hill.	...	37 1/2		...	...	...	...	...	...	...	...		22	330 1/2
	Broken Hill-C. Border . .	...	12 1/4		...	...	...	...	...	...	...	119 3/4		...	...
Light rails :	Selukwe Branch	...	23 1/4	Not expressed.	...	...	...	...	...	...	...	...	Not expressed.	1	...
	West Nicholson Branch .	...	...		...	...	...	...	...	...	1	...		1	102 3/4
	Lomagundi Branch. . . .	...	...		...	...	...	...	...	...	...	3 3/4		...	78 3/4
	Blinkwater Branch. . . .	...	...		...	...	...	...	...	...	...	123 1/2		...	...
	Mazoe Branch	...	...		...	...	...	...	...	...	...	73		...	...
	Shabani Branch	...	62 1/2		...	...	...	...	...	...	...	...		...	...
	Total. . .	1	277 3/4	...	...	80	...	...	...	...	1	320	...	52	1246 1/2

Number of train-miles : 5 015 243. — Total number of fractures : 54.

(1) Except one n 4 pieces

Note : Trucks with axle loads of 13 tons 18 cwt.

AILWAY.				Classification according to part II of suggestions adopted at the General Meeting of the London Congress in 1925.						
				A Percentage of fractures in respective portions of the rails covered by and clear of the fishplates.		B Percentage of fractures according to the appearance of the fracture :				
	Maximum axle load (engines).	Maximum speed of trains permitted.	REMARKS.	a) Percentage covered by fishplates.	b) Percentage clear of fishplates.	a) Fresh and clean fracture through whole of rail section.	b) Fractures part of which is old and much rusted extending to outer face of foot or head of rail.	c) Fractures with much rusted portions not extending to outer face of foot or head of rail.	d) Number of pieces into which rail is broken.
	19	20	21	22	23	24	25	26	27
	Tons. Cwt.	Miles per hour.							
349	9—12	30	...	...	...	...	...	...	2 pieces.
299	12—18	30	...	...	100.00	33.33	66.67	...	2 pieces.
509	13—00	35	...	...	100.00	100.00	...	...	2 pieces.
509	13—00	35	...	25.00	75.00	62.50	37.50	...	2 pieces.
104	13—00	35	...	22.22	77.78	22.22	44.45	33 33	2 pieces.
045	13—00	35	...	31.81	68.19	22.72	77.28	...	2 pieces. (1)
446	12—18	35	...	...	...	...	...	...	2 pieces.
257	9—12	25	Engines of 13 tons axle load run occasionally on this branch.	...	100 00	...	100.00	...	2 pieces
738	12—01	30	Engines of 13 tons axle load permitted at speed of 20 miles per hour.	...	100.00	100.00	...	...	2 pieces.
212	9—12	30	Engines of 12 tons 18 cwt. axle load permitted at speed of 25 miles per hour.	...	100.00	...	100.00	...	2 pieces.
723	12—01	30	Engines of 13 tons axle load permitted at 25 miles per hour.	...	...	...	...	...	2 pieces.
032	9—12	30	Engines of 12 tons 18 cwt. axle load permitted at 25 miles per hour.	...	...	...	...	...	2 pieces.
020	9—12	25	Engines of 12 tons 18 cwt. axle load permitted at 20 miles per hour.	...	...	...	...	...	2 pieces.
243	...	...	...	24.11	75.89	37.10	57.40	5.50	...

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : not expressed.

full capacity run over all sections of the line.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Nigerian Railway.		Miles.						Miles.			Miles.					English tons.
Light rails.	30	483 1/2	38.7	...	...	...	2	151	8 2	4	646	3.8	...	...	...	16

Total number of fractures : 36.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	*Light rails* : of 17.5 to 23 kgr. per metre (35 to 46 1/4 lb. per yard).	*Medium rails* : of 30 to 30.5 kgr. per metre (60 to 61 lb. per yard).	*Heavy rails* : of 37.5 to 42.5 kgr. per metre (75 to 85 lb. per yard).
South African Railways and Harbours.			
Age of rails :			
Less than 5 years	1	42	41
5 to 10 years	...	4	19
10 to 15 years	...	6	42
15 to 20 years	1	4	79
Over 20 years	66	84	67
Age unknown (marks undecipherable)	78	131	41
Number of fractures	146	271	289
Length of single track (miles)	2 537	5 872	4 261
Number of fractures per 1 000 kilometres or 625 miles	35.97	28.84	42.39
Maximum axle load (English tons)	10.5	13.5	18.5

Total miles : 12 670.
Number of train-miles : 49 391 127.
Total number of fractures of all classes of rails : 706.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 89.34.

NOTE : The above fractures include those occurring in sidings as well as in running tracks.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Sudan Government Railways and Steamers. (*)																
Light rails:																
50 lb. per yard	...	135.5	...	...	215.6	...	...	...	...	...	...	...	5	801.6	3.95	12
75 lb. per yard	...	21.1	...	...	34.8	...	...	13.7	...	...	489.7	...	1	109.4	5.68	16
Total	...	156 6	...	...	250 4	...	...	13.7	...	...	489 7	...	6	911.0	4.16	...

Number of train-miles : 2 020 900.
Total number of fractures : 6.

Number of fractures per 10 000 000 train-kilomètres or 6 250 000 train-miles : 18.48.

(*) Exclusive of sidings.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
AUSTRALASIA.																
New South Wales Government Railways.																
Light rails	2	5 966	0.209	2	5 966	0.209	1	5 966	0.104	20	5 966	2.09	26	5 966	2.72	20.35
Medium rails	...	672	...	1	672	0.93	1	672	0.93	...	672	...	1	672	0.93	20.35
Total. . .	2	6 633	0.188	3	6 638	0.282	2	6 638	0.188	20	6 638	1.88	27	6 638	2.54	...

Number of train-miles : 26 896 580.

Total number of fractures : 54.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 12.54.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
New Zealand Government Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	370	...	1	303	2.05	2	342	3	25	665	23.4	49	1 660	18.4	14
Medium rails	..	10	...	...	...	...	1	...	...	...	...	...	...	...	...	14
Total. . .	...	...	...	1	...	...	3	...	...	25	...	...	49	...	...	...

No rails over 100 lb. per yard in use.
Number of train-miles : 10 970 000.
Total number of fractures : 78.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 44.5.
Number of fractures at joints : 54 = 69 °/₀ of total.
Number of fractures away from joints : 24 = 31 °/₀ of total.

PARTICULARS OF THE FRACTURES.		Number.	Percentage of total.
a) Fresh and clean fracture in the whole of the rail section.	with silvery oval mark.	...	...
	without silvery oval mark	4	5
b) Fracture, part of which is old and much rusted, extending to the outer surface of the foot or the head of the rail	in the foot	28	36
	in the head.	16	20
c) Fracture, part of which is old and much rusted, not extending to the outer surface of the foot or the head of the rail	. . . . . .	30	39

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		
CANADA.																
Canadian National Railways.	...	...														
Light rails	...	...	...	23	45	319	1354	521	1 624	13 784	3 811	2 261	No information.			...
Medium rails	1566	3 299	297	8223	3 137	1 638	794	305	1 627	996	191	3 259	166	96	1 081	...
Total	1566	3 299	297	8246	3 182	1 619	2148	826	1 625	14 780	4 002	2 308	166	96	1 081	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Quebec Central Railway.																
Light rails	1A2	...	...	...	...	...	...	...	...	...	...	...	1A1	...	...	...

Total number of fractures: 2.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
														Miles.		English tons.
Asia.																
CEYLON.																
Ceylon Government Railways.																
Light rails:																
46 1/4 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	2	406.6	5.27	9
72 and 80 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	5	418.3		14
Medium rails:																
88 and 90 lb. per yard.	...	...	...	...	...	...	...	...	...	...	...	...	...	196.6	...	16
Total. . .	...	...	...	...	...	...	...	...	...	...	...	...	7	1 021.5	4.26	...

Number of train-miles : 4 800 095.
Total number of fractures : 7.

All fractures occurred clear of the fishplates.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 9.1.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
INDIA.																
Bengal Nagpur Railway (*)																
Light rails	2	69.32	18.03	...	61.24	...	...	1.07	...	7	293.47	14.91	12	1 064.12	7.04	17.25
Medium rails	8	462.93	10.80	1	28.22	22.15	...	3.73	...	2	14.08	88.78	5	1 253.26	2.49	
Total. . .	10	532.25	11.74	1	89.46	6.98	...	4.8	...	9	307.55	18.28	17	2 317.38	4 58	

(*) Year 1928-1929.

Number of train-kilometres or train-miles : 14 038 575.
Total number of fractures : 37.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 16.47.

Bengal and North Western Railway. *	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles			Miles.			Miles		
Light rails	...	359.72	...	...	0.96	...	...	122.32	...	...	197.22	...	20	1 393.9	8.94	...

(*) Year 1928-1929.

Number of train-miles . 7 335 483.
Total number of fractures : 20.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 17.04

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bombay, Baroda and Central India Railway. (Broad gauge.)								Miles.			Miles.					English tons.
Medium rails	...	...	...	...	...	...	2	1 221.190	1.02	2	1 221.190	1.02	...	...	...	18

Number of train-miles on the whole of the broad gauge system for the year ending 31 December 1928 : 8 641 000.

Total number of fractures during the year ending 31 December 1928 : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.89.

Note. — It is not possible to give percentage of fractures in the respective portions of the rails covered by and clear of the fishplates; percentage of fractures according to the appearance of the fracture is not available.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															Maximum axle load.
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
								Miles.			Miles.			Miles.		English tons.
Bombay, Baroda and Central India Railway. Metre (3 ft. 3 ⅜ in.) gauge system.																
Light rails :																
of a weight of :																
41 ¼ lb. per yard.	...	...	...	...	...	...	...	1 162.51	...	1	1 162.51	0.53	16	1 162.51	8.60	8
50 lb. per yard.	...	...	...	...	...	...	1	1 271.37	0.49	...	1 271.37	...	17	1 271.37	8.35	10
60 lb. per yard.	...	...	...	...	...	...	...	422.02	...	...	422.02	...	...	422.02	...	10.5
Total. . .	...	...	...	...	...	...	1	2 855 90	0.22	1	2 855.90	0.22	33	2 855.90	7.18	...

Number of train-miles : 9 760 000.
Total number of fractures : 35.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 22.41.

Notes. — All fractures were outside the portion covered by the fishplates.
Percentage of fractures according to the appearance of the section is not available.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Burma Railways.					Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :																
50 and 60 lb. per yard.	...	...	...	1	1 800	0.347	1	1 800	0.347	2	1 800	0.694	3	1 800	1.04	10

Number of train-miles : 8 258 820.
Total number of fractures : 7.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 5.3

1	2	3	4	5			8	9	10	11	12	13	14	15	16	17
Eastern Bengal Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	2	3 992.50	0.31	...	...	...	3	3 992.50	0.46	4	3 992.50	0.62	17	3 992.50	2.66	...
Medium rails, ...	2	1 594.50	0.78	1	1 594.50	0.39	8	1 594.50	3.13	3	1 594.50	1.17	...	...	...	...

Number of train-miles : 10 511 214.
Total number of fractures : 40.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 23.78.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
East Indian Railway. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	...	865	...	...	865	...	...	865	...	2	865	...	8	865	...	...
Medium rails	8	2 205	...	6	2 205	...	6	2 205	...	1	2 205	...	...	2 205	...	...

(*) Year 1928-1929.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles	More than 20 years. Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Indian Peninsula Railway. (*)	Age of rails (from year of manufacture).															English tons.
Light rails:																
35 lb. per yard	...	...	...	...	...	...	2	...	...	...	...	...	1	...	...	7
62 lb. —	...	...	...	...	...	...	...	...	...	1	...	...	13	...	...	13.5
69 lb. —	...	...	...	1	...	...	5	...	...	1	...	...	7	...	...	13.5
75 lb. —	...	...	...	...	...	...	2	...	...	...	...	...	44	...	...	16.5
80 lb. —	...	...	...	...	...	...	...	...	...	1	...	...	5	...	...	17.5
82 lb. —	...	...	...	3	...	...	6	...	...	2	...	...	1	...	...	18.6
85 lb. —	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	20
	...	...	...	4	...	...	15	...	...	5	...	...	71	...	...	...
Medium rails:																
100 lb. per yard	...	...	...	1	...	...	3	...	...	...	...	...	...	...	...	20

(*) Year ended 31 December 1928.

Number of train miles : 28 785 232
Total number of fractures : 99.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 21.5 .

	RAILS OF:							
	35 lb.	62 lb.	69 lb.	75 lb.	80 lb.	82 lb.	85 lb.	100 lb.
Miles of railway including sidings	180.304	56 910	747.021	620.597	910.760	1 548.414	122.837	1 207.727

(*) The above table shows the total mileage of each section of rails in use on the Great Indian Peninsula Railway, and on which there were fractures. But it is not possible to give the total mileage according to age as no record exists, but no rails of the following sections were ordered or purchased for the last 20 years : 60, 62, 69, 75, 80, and 85 lb. The last year of purchase of 82-lb. rails was 1923-1924

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Madras and Southern Mahratta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	1	527.75	1.18	...	148.70	...	...	199.255	...	...	327.75	...	23	1 567.3	9.17	17.9
Medium rails	1	197.5	3.16	...	144.125	...	...	...	...	...	...	...	...	...	...	17.95
Total	2	724.875	1.72	...	292.825	...	...	199.255	...	...	327.75	...	23	1 567.3	9.17	...

Number of train-miles : 15 574 000.
Total number of fractures : 25.

Number of fractures per 10 000 000 train kilometres or 6 250 000 train-miles : 10.03.

CLASSIFICATION OF BREAKAGES.

	Total number of breakages.	A		B				
		Percentage of breakages.		Percentage of fractures as per appearance.				
				a) Fresh and clean		b) Fractures parts of which is old and much rusted.		c) Percentage of fractures with much rusted portions not extending to the outer face of foot or head.
		Covered by fishplate.	Clear of fishplate.	1. With silvery oval mark.	2. Without silvery oval mark.	1. Rusted part in the foot.	2 Rusted part in the head.	
Light rails	24	8.33	91.67	8.33	12.50	54.17	20.83	4.17
Medium rails	1	0	100	100	0	0	0	0
Total	25	8	92	12	12	52	20	4

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															Maximum axle load
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
North Western Railway (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	356.69	...	2	579.5	2.16	2	333.02	3.75	14	719.41	12.16	40	3 059.80	8.17	17.0
Medium rails	3	523.20	3.58	1	396.3	1.58	5	373.78	8.36	5	413.80	7.55	3	683.81	2.74	19.7
Total. . .	3	879.89	...	3	975.8	...	7	706.80	...	19	1 133.21	...	43	3 743.61	...	...

(*) Year ending 31 March 1929.

Number of train-miles : 29 630 594.
Total number of fractures : 75.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 15.82

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rohilkund and Kumaon Railway.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	...	571.94	...	9.5

Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
South Indian Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	1	483.62	1.29	...	143.56	...	1	281.61	2.22	...	41.25	...	3	1 621.18	1.20	7.80 [1] 8.15 ( ) 10.00 [3]
Medium rails	...	55.14	...	...	76.89	...	...	...	...	...	...	...	...	0.25	...	18

Number of train-miles : 11 085 828.
Total number of fractures : 5.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.81.

(1) For 35 lb. rails. — (2) For 40 and 41 1/4 lb. rails. — (3) For 50 to 75 lb. rails.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.												Miles.		English tons.
MALAY PENINSULA.																
Federated Malay States Railways.																
Light rails :																
of a weight less than 42.5 kgr. per metre or 85 lb. per yard.	1	1 285	0.49	...	...	...	...	...	...	...	...	...	1	1 285	0.49	12

Number of train-miles : 5 555 272.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 2.25.

1	
IRISH FREE STATE.	
County Donegal Railways Joint Committee. — **Great Northern Railway.**	(See under : « Great Britain & North of Ireland »).

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Great Southern Railways.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	20	1 339.71	9.3	18.5
Medium rails	...	...	...	...	...	...	...	...	...	...	...	...	3	1 267.28	1.4	18 5
Total . . .	...	...	...	...	...	...	...	...	...	...	...	...	23	2 606.95	...	...

Number of train-miles : 9 405 469.
Total number of fractures : 23.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 trains-miles : 15.3.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															*Maximum axle load*
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
														Miles.		English tons.
GREECE.																
State Railways.																
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	18	777.77	14.38	15

Number of train miles : 2 331 720.
Total number of fractures : 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 47.96.

1	2	3	4	5		7	8	9	10	11	12	13	14	15	16	17
														Miles.		English tons.
Thessaly Railways.																
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	4	125.5	19.8	9.2

Number of train-miles : 264 652.
Total number of fractures : 4.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 93.92.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Rails in use for					TOTAL.	Approximate length of the lines considered as single line.	Number of fractures per 1 000 km. or 625 miles	Maximum axle load in service.
	Less than 5 years.	5 to 10 years.	10 to 20 years.	20 to 30 years.	More than 30 years.				
	Number of fractures.	Number of fractures.	Number of fractures.	Number of fractures.	Number of fractures.				
1	2	3	4	5	6	7	8	9	10
ITALY. State Railways.							Miles.		
Light rails	6	14	43	86	797 (1)	946	8 401	69.9	16.2
Medium rails :									
In tunnel	2	37	296		...	338	199	1 056.2 } 61.2	16.7
In the open	7	9	27	2	...	45	3 688	7.5 } 61.2	...
Total. . .	9	46	323	5	...	383	3 887	...	...
Total general. . .	15	60	366	91	797	1 329	12 288	67.2	...

Number of train-miles : 87 402 195.
Total number of fractures : 1 329.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 94.4.

Note. — Nearly all the fractures of medium rails (338 on 199 miles of track) occurred in tunnels, in which unfavourable conditions besides dampness due to water infiltration, make maintenance very difficult, whereas in the open only 45 breakages on 3 688 miles of track, occurred.

Tessin Railways.	No rail fractures in 1928.
Società Trazione Elettrica Lombarda.	No rail breakage reported in 1928.

1) Most of these rails were put into service more than forty years ago.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
JAPAN.																
Japanese Government Railways. (*)																
Light rails	33	3 055.6	6.7	67	2 233.4	18.7	69	1 175.2	36.5	144	728.4	123	119	3 162.5	23.4	16.41

(*) Year 1927.

Number of train-miles : 101 819 900.
Total number of fractures : 432 (including 7 of unknown age).

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 26.4.

A. — Percentage of fractures in the respective portion of the rails :

1. Covered by the fish-plates . . . . 28 %.
2. Clear of the fish-plates . . . . 72 %.

Note. — This is based on the statistics of breakages of rails in 1927.

B. — Percentage of fractures according to the appearance of the fracture :

	In 1926.	In 1927.
a) Fresh and clean fracture through the whole of the rail section, *with* silvery oval mark	14.0 %.	27.0 %.
b) Fresh and clean fracture through the whole of the rail section, *without* silvery oval mark . . .	12.0 %.	10.0 %.
c) Fractures, part of which is old and much rusted, extending to the outer surface of the rail, with the rusted part in the foot	4.0 %.	4.0 %.
d) Fractures, part of which is old and much rusted, extending to the face of the rail, with the rusted part in the head	22.5 %.	8.0 %.
e) Fractures, with much rusted portions not extending to the outer surface of the foot or head of the rail	15.0 %.	19.0 %.
f) Rails broken into several pieces (*light rails*) . . .	32.5 %.	32.0 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Japanese Government Railways (*).		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	64	3 119.5	12.7	40	2 018.9	12.3	45	1 061.5	26.3	67	604.2	69	100	2 797.5	22.2	16.41
Medium rails.	1	243.9	2.6	...	...	...	...	...	...	...	...	...	...	...	...	...

(*) Year 1928.

Number of train-miles : 106 671 925.
Total number of fractures : 320 (including 3 of unknown age).

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 18.6.

Percentage of fractures of rails covered by and clear of fish-plates :

Damaged part of rails:	Percentage.	*Remarks.*
Covered by fish-plates.	32.8	This is based on statistics of rail breakages in *1926*.
Clear of fish-plates	67.2	
Total. . . .	100.00	

Percentage of fractures according to the appearance of the fracture :

	Light rails.	Medium rails. In 1928
a) Fresh and clean fracture through the whole of the rail section, with silvery oval mark	17.5 %	0.3 %
b) Fresh and clean fracture through the whole of the rail section, without silvery oval mark .	5.7 %	...
c) Fractures, part of which is old and much rusted, extending to the outer surface of the rail, with the rusted part in the foot	8.4 %	...
d) Fractures, part of which is old and much rusted, extending to the face of the rail, with the rusted part in the head	10 %	...
e) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail.	28.1 %	...
f) Rails broken into several pieces	30 %	...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails:															*Maximum axle load*
	Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Government Railways of Chosen. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	15	1 268.5	7.4	7	1 172.8	3.7	15	975.7	9.6	18	505.4	22.3	45	291.7	96.4	19.3
Medium rails	0	34.5	...	...	...	...	...	...	...	...	...	...	...	...	..	19.3
Total . .	15	1 303.0	7.4	7	1 172.8	3.7	15	976.7	9.6	18	505.4	22.3	45	291.7	96.4	...

(*) Year 1926.

Number of train-miles : 6 142 976.
Total number of fractures : 100.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 101.7.

PARTICULARS OF THE FRACTURES ACCORDING TO THE APPEARANCE OF THE SECTION.

Description of rails.	Age of rails.	A_1	A_2	Ba_1	Ba_2	Bb_1	Bb_2	Bc	Bd
		Per cent							
Light rails.	Less than 5 years.	33	67	..	27	40	27	6	100
	5 to 10 years.	14	86	...	28	14	29	29	100
	10 to 15 years.	27	73	...	33	33	...	34	100
	15 to 20 years.	17	83	...	39	17	5	39	100
	More than 20 years.	51	49	...	4	20	29	47	100

Remark : This report does not include rails broken in sidings, etc...

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km or per 625 miles	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles	Maximum axle load
Government Railways of Chosen. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	8	1 321.8	3.8	8	1 199.3	4.2	38	1 028.0	23.1	11	715.1	9.6	50	[illegible]91.4	107.3	19.3
Medium rails	...	41.9	...	...	[illegible].9	...	...	...	...	...	...	...	...	...	...	19.3
Total	8	1 363.7	3.8	8	1 205.2	4.2	38	1 028.0	23.1	11	715.1	9.6	50	291.4	107.3	...

(*) Year 19[illegible]7.

Number of train-miles: 6 [illegible]81 401 miles.
Total number of fractures: 115.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 107.6.

PARTICULARS OF THE FRACTURES ACCORDING TO THE APPEARANCE OF THE SECTION.

Description of rails.	Age of rails.	A_1	A_2	Ba_1	Ba_2	Bb	Bb_2	Bc	Bd
		Per cent							
Light rails	Less than 5 years.	13	81	...	13	62	25	...	100
	5 to 10 years.	25	75	...	...	25	13	62	100
	10 to 15 years.	11	89	...	8	13	34	45	100
	15 to 20 years.	...	100	...	18	36	28	18	100
	More than 20 years.	54	46	...	6	23	17	54	100

Note: A_1 = Percentage of breakages covered by fishplates.
A_2 = — — clear of fishplates.
Ba_1 = — — with silvery oval mark.
Ba_2 = — — without silvery oval mark.
Bb_1 = — — part of which is much rusted extending to the outer surface of the foot of the rail.
Bb_2 = — — — — — — — — — — head of the rail.
Bc = — — with much rusted portions not extending to the outer surface of the foot or head of the rail.
Bd = — of rails broken into two pieces or more.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
LUXEMBURG.																
Guillaume-Luxemburg Railways.	(See under « Alsace and Lorraine Railways ».)															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Prince Henry Railways and Mines.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	1	19.4	32.0	2	9.1	135.3	1	21.4	29.0	1	22.6	27.4	4	22.63	109.8	15.7
Medium rails	...	29.4	...	...	3.8	...	...	10.0	...	...	...	...	...	...	...	15.7
Total . .	1	48.8	12 7	2	12.9	96.4	1	31.4	19.7	1	22.6	27.4	4	22.63	109.8	...

Number of train-miles : 914 144.
Total number of fractures ; 9,

Number of fractures per 10 000 000 train-kilometres or 6 250 000 trains-miles : 61.2.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS.	Length of single track of this class.	Age of rails : Less than 5 years.		5 to 10 years.		10 to 15 years.		15 to 20 years.		More than 20 years.		TOTAL		Maximum axle load.
		Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Per 1 000 km. or per 625 miles.	
NORWAY.	Miles.													Pounds.
State Railways.														
Light rails.	2 154	2	0.6	19	5.5	20	5.8	6	1.7	84	24.2	131	37.8	39 680

Number of train-miles : 8 110 300.

Total number of fractures : 131.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 100.

Classification of fractures :

A. — At the joint : 47.3 %.

B. — *a)* New clean break : 45 %.

b) With rusted part : 1. in the base : 32.1 % ; 2. in the head : 22.1 %.

c) With other oxidation : 0.8 %.

d) Number of pieces of broken rail : 2 pieces, 100 %.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
HOLLAND.																
Netherlands Railways (Netherlands State Railway Company and Dutch Railway Company)																
Light rails	1	121.2	5	12	395.4	19	13	292.0	28	17	651.9	16	143	979.9	91	15.7
Medium rails	9	162.2	34	1	311.9	22	...	231.2	...	...	77.7	...	4	59.7	42	19 7
Heavy rails.	The Company does not use heavy rails.															
Total . .	10	...	...	13	...	...	13	...	...	17	...	...	147	...	...	...

Number of train miles: 0 29 0 0.
Total number of fractures: 210.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train miles: 43.

	Light rails :	*Medium rails :*	Remarks
Netherlands Railways.			
A. — Percentage of fractures in the respective portions of the rails :			
a) Covered by the fishplates	54 %	63 %	
b) Clear of the fishplates	46 %	37 %	
B. — Percentage of fractures according to the appearance of the fracture :			
a) Fresh and clean fracture through the whole of the rail section :			The attention of the permanent way staff is not yet sufficiently directed to noticing fractures with silvery oval marks.
1. With silvery oval mark . . . . / 2. Without silvery oval mark	53 %	58 %	
b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rail :			
1. Rusted part in the foot.	43 %	33 %	
2. Rusted part in the head	3 %	...	
c) Fractures with much rusted parts not extending to the outer surface of the foot or head of the rail	1 %	9 %	
d) Number of pieces into which the rail is broken : two	89 %	88 %	
— — — — three.	11 %	12 %	

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Miles.			Miles.			Miles.			Miles.			Miles.		
COLONIES. Dutch India State Railways. (Java, Sumatra and Celebes). *Light rails:*																
Number and percentage of fractures in the portion of the rail covered by the fish plates.	...	405.8	6	...	392.7	3	...	...	...	...	250 4	...	2 (1)	1 305.5	1	...
Number and percentage of fractures clear of the fish plates.	4 (2)	...	...	2 (2)	...	...	...	...	...	...	...		27 (3)		13	...
Number and percentage of:																
a) Clean and fresh breaks through the whole of the rail section	1 (4)	...	...	1 (5)	...	...	...	...	...	...	...	...	4 (6)	...	...	...
b) Breaks with old part extending to the outer surface of the:																
1. Foot of the rail	2 (5)	...	...	1 (5)	...	...	...	...	...	...	...	...	9 (7)	...	...	...
2. Head of the rail	1 (4)	...	...	...	...	...	...	...	...	...	...	...	3 (8)	...	...	...
c) Breaks with old part not extending to the outer surface of the rail	...	...	...	...	...	...	...		...	...	...	...	13 (9)	...	...	...
d) Number of pieces the rail is broken into	2	...	...	2 (*a*)	...	...	...	...	...	...	...	...	2 (*b*)	...	...	...

Number of train-miles : 15 703 000.
Total number of fractures : 35.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 14.

(1) 6.9 %. — (2) 100 %. — (3) 93.1 %. — (4) 2.5 %. — (5) 50 %. — (6) 13.8 %. — (7) 31 %. — (8) 10.3 %. — (9) 44.9 %.

(*a*) In one case the fracture was not complete. — (*b*) In 5 cases, the fracture was not complete.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Dutch India Railway Company.											Miles.			Miles.		English tons.
Light rails :																
25.7 kgr. (51.8 lb. per yard)	...	...	...	...	...	...	...	...	...	1	28.0	22	...	...	...	12.2
33.5 kgr. (67.6 lb. per yard)	...	...	...	...	...	...	...	...	...	...	...	...	1	146.0	4	13.8

Number of train-miles : 2 868 500.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 4

Fractures at the joint : 1; outside the joint : 1.
No silvery oval mark.
The fracture in the 51.8-lb. rail was old; a small portion of it in the head next to the rolling surface was new and of oval shape.
The outer surface of the head was not severed for a depth of 3/64 inch.
The break in the 67.6-lb. rail was new in the head and in the web, and old in the foot, wherein it extended for 1-9/16 inches. This rail was broken into several pieces.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
POLAND. State Railways. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	77	1 095	43.6	21	294	44.3	148	1 898	48.4	134	3 180	26.1	1209	7 499	100.1	...
Medium rails	...	...	...	...	...	...	2	...	...	1	...	...	...	...	...	...
Total.	77	1 095	43.6	21	294	44.3	150	1 898	48.4	135	3 180	26.1	1209	7 499	100.1	...

(*) Year 1927.

Number of train-miles : 69 074 000.
Total number of fractures : 1 592.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 143.3.

Characteristics of the fractures :

A. — Percentage of fractures in the joint : 41 % and clear of the joint : 59 %.

B. — *a)* Percentage of clean new fractures through the full section of the rail (silvery oval marks not having been recorded) : 44 %.
b) 1. Percentage of fractures, part of which is old and much rusted, extending to the outer surface of the rail : 21 %.
b) 2. Percentage of fractures with rusted part in the head of the rail : 15 %.
c) Percentage of fractures with old rusted part not extending to the outer surface of the foot or the head : 20 %.
d) No information.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
POLAND. State Railways. (*)		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	112	1 363	55.6	36	320	66.9	120	1 395	53.9	219	3 119	44.4	1642	7 684	133.2	...
Medium rails	10	...	...	...	...	...	1	...	...	4	...	...	5	...	...	...
Total . . .	122	1 363	55.6	36	320	66.9	121	1 395	53.9	223	3 119	44.4	1647	7 684	133.2	...

(*) Year 1928.

Number of train-miles: 74 143 300.
Total number of fractures: 2 149.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles: 180.

CHARACTERISTICS OF THE FRACTURES.

A. — Percentage of fractures at the joint : 43 °/. and clear of the joint : 57 °/..

B. — *a*) Percentage of clean new fractures through the full section of the rail (silvery oval marks not having been recorded) : 40 °/..

b) 1. Percentage of fractures, part of which is old and much rusted, extending to the outer surface of the rail : 20 °/..

b) 2. Percentage of fractures with rusted part in the head of the rail : 14 °/..

c) Percentage of fractures, part of which is rusted, not extending to the outer surface of the foot or the head : 26 °/..

d) No exact information. Cases of rails broken in more than 2 pieces are exceedingly rare.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
PORTUGAL. Portugeese Beira Alta Railway.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	18(1)	68.4 (2)	163.6	13.8

Number of train-miles : 538 334.
Total number of fractures : 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 207.7

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Portuguese Railway Company.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	128.89	...	...	97.69	...	15	102.35	91.06	...	...	...	520	1 112.73	290.37	15.7
Medium rails	...	95.42	...	1	20.34	30.55	1	35.42	17.54	...	22.43	...	2	76.30	16.20	17.3
Total. . .	...	224.31	...	1	118.03	5.26	16	137.77	72.16	...	22.43		522	1 189.03	272.79	...

Number of train-miles : 7 729 530.
Total number of fractures : 539.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 433.30.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
COLONIES. Colonial State Railways. San Tomé Railway.								Miles.								Pounds.
Light rails	...	...	...	...	...	...	...	12.1	...	...	...	...	...	...	...	5 378

(1) Fractures due to variations in temperature : 10
— — to old cracks : 2
— — to wear of equipment : 6 } 18

(2) 30 kgr. (60.5 lb. per yard rails). — The remainder of the system, *i. e.* 89 miles, is equipped with 40-kgr. (80.6 lb. per yard) rails, and no breakage was reported on that part.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			Maximum axle load
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
RUMANIA.		Miles.			Miles.											
State Railways.																
Light rails	56	198.2	175.5	24	74.6	2.27	106	...	10.2	131	...	12.38	2280	...	215.46	...
Medium rails	358 (¹)	197.6	1126.0	...	...	...	2	...	2.58	6	...	7.75	...	...	...	...
Total. . .	414	395.8	649.9	24	74.6	2.27	108	...	...	137	...	...	2280	...	215.46	...

Number of train-miles : 36 021 175.

Total number of fractures : 3 366 (in the running track : 2937 ; in sidings : 429).

Total length of single track : 7 056.

Fractures at the joint : 1 068.

Fractures outside the joint : 2 298.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 586.3

The above table does not include 403 additional fractures of rails of unknown age.

(¹) Of these 349 were type 45 rails broken a few months after being laid in the track, owing to bad manufacture (Thomas steel, over 75 kgr. per mm² (47.6 Engl. tons per sq. inch) ultimate stress.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWEDEN.		Miles.			Miles.			Miles.			Miles.			Miles.		
State Railways.																
Light rails	11	5 353	1.3	17	5 353	2	12	5 353	1.4	59	5 353	6.8	125	5 353	14.5	17.2
Medium rails	32	314	63.2	...	...	...	...	...	...	...	...	...	...	...	...	17.2
Total	43	5 667	4.7	...	...	...	...	...	...	...	...	...	...	...	...	...

Number of train-miles : 17 880 700.
Total number of fractures : 256.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 88.96.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Göteborg-Borås and Borås-Alfvesta Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :	...	7.5)	...	...	15.5 (1)	...	...	26.1 (1)	...	...	1.2 (1)	...	...	111.8 (2)	...	13.8

No fractures of rails in 1928.
Number of train-miles : 749 400.

No broken rails on this system in 1928.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Göteborg-Dalarne-Gäfle Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails :	...	116.2	...	1	85.8	7.3	2	55.9	22.2	3	51.0	36.6	2	134.8	9.2	12.3
Medium rails :	...	34.2	...	2	99.4	12.5	2	80.8	15.4	...	82.6	...	...	...	...	17.0
Total	...	150.4	...	3	185.2	10.1	4	136.7	18.1	3	133.6	13.9	2	134.8	9.2	...

Number of train-miles : 308 830.
Total number of fractures : 12.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 24.2.

(1) 41.18 kgr. (83 lb. per yard). — (2) 32 kgr. (64.5 lb. per yard).

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load.*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Halmstad-Nässjö Railway.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	...	33.0	...	...	56.3	...	...	6.	...	...	5.3	...	...	152.7	...	...
Number of train-miles : 856 950.										No fractured rails in 1928.						
Kalmar-Nya Railway.	No fractured rails in 1928.															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Karlstad-Munkfors-Nordmarks-Klarelfvens-Filipstads-Nora-Bergslagen Railway.														Miles.		English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	8	106.0	35	4.65
Number of train-miles : 366 457. Total number of fractures : 6.										Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 102.						
Nässjö-Oskarshamn Railway.	No broken rails on this system in 1928.															
Nora-Bergslagen Railway.	No fractured rails in 1928. Number of train-miles : 254 495.															

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Stockholm-Västerås Bergslagen Railway											Miles.			Miles.		
Light rails : 31.2 kgr. (62.7 lb. per yard.)	...	...	...	...	...	...	...	...		...	...	...	4	268.4	9.2	...
Medium rails : 43.5 kgr. (87.7 lb. per yard).	...	...	...	...	...	...	...	...	...	...	29.8	...	...	...	...	

Number of train-miles : 1 268 890.
Total number of fractures : 4

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 19.6

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Trafikaktiebolaget Grängesberg-Oxelösund Jarnväger (*)								Miles.			Miles.			Miles.		English tons.
Light rails :																
(1) In 1926	...	...	...	...	..	...	...	8.95	...	1	65.43	9.5	10	134.47	46.3	14.1
(2) In 1927	...	...	...	...	...	...	...	8.95	...	1	12.30	50.6	8	187.00	26.5	15 2
In 1928	...	...	...	...	...	...	...	3.98	...	...	14.35	...	7	190.45	22 84	15 2

* Years 1926 to 1928.

Number of train-miles :

(1) In 1926 : 1 113 054
(2) In 1927 : 1 209 749
In 1928 : 955 842

Total number of fractures :

In 1926 : 11
In 1927 : 9
In 1928 : 7

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles :

In 1926 : 61.4
In 1927 : 46.2
In 1928 : 45.5

(1) Corrected figures for « Oxelösund-Flen-Västmanlands » ; see *Bulletin*, October 1927 number, p. 915.
(2) — — — — — — — — — November 1928 number, p. 1016.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Västergötland-Göteborg Railway.																English tons.
Light rails	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	8.7

Number of train-miles : 539 000.
Total number of fractures : 0.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 0.

Names of administrations and description of rails	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SWITZERLAND. Federal Railways.																English tons.
Light rails: Total : 1 703.8 miles.	1	...	...	3	...	...	3	...	...	3	...	...	127	...	...	20.1
Medium rails: Total : 1 876.6 miles.	4	...	...	17	...	...	39	...	..	21	...	...	48	...	...	20.1
Total : 3 580 4 miles.	5	...	...	20	...	...	42	...	...	24	...	...	175	...	...	...

Number of train-miles : 22 832 680.
Total number of fractures : 266.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 72.4.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Berne Alpine Railways. Berne-Loetschberg-Simplon. *a*) Loetschberg Line.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails	...	4.50	...	...	0.95	...	...	...	...	...	1.24	...	...	11.98	...	16.2
										8	42.13	118	...	7.23	...	19.7
Medium rails	...	0.62	...	...	1.96	...	...	0.19	...	...	9.66	...	...	...	...	19.7
	...	3.29	...	9	1.49	3 750	1	2.89	215							
Total. . .	...	8.41	...	9	4.40	1 272	1	3.08	202	8	53.03	93	...	19.21	...	...

Number of train-miles : 835 040.
Total number of fractures : 18.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 134.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	*Maximum axle load*
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
b) **Erlenbach-Zweisimmen Line.**		Miles.												Miles.		English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.68	...	...	...	...	...	...	...	...	...	...	...	13.09	...	12.51
Number of train-miles : 80 482.																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
c) **Spiez-Erlenbach Line.**		Miles.			Miles.									Miles.		English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.80	...	...	0.46	...	...	...	...	...	...	...	...	4.29	...	12.51 (locom.)
Number of train-miles : 47 412.																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
d) **Berne-Schwarzenburg Line.**		Miles.			Miles.											English tons.
Light rails: 26 kgr. (52.4 lb. per yard.)	...	1.54	...	...	0.27	...	...	...	...	...	...	...	1	9.10	68	12.51

Number of train miles ; 66 688.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 93.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails : Less than 5 years.			5 to 10 years.			10 to 15 years.			15 to 20 years.			More than 20 years.			*Maximum axle load*
	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	Number of fractures.	Length of single track of this class.	Number of fractures per 1 000 km. or per 625 miles.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
e) **Gürbethal Line.**		Miles.			Miles.									Miles.		English tons.
Light rails : 25.75 kgr. (51.9 lb. per yard).	...	2.70	...	...	0.54	...	...	...	...	...	...	...	1	15.87	39	12.51 (locom.)

Number of train-miles : 195 653.
Total number of fractures : 1.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 31.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
f) **Berne-Neuenburg Line.** (Direct line)		Miles.			Miles.			Miles.						Miles.		English tons.
Light rails : 36 kgr. (72.6 lb. per yard.)	...	0.58	...	...	0.18	...	...	0.50	...	...	...	...	...	23.21	...	17.6 (locom.

Number of train-miles : 258 967.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Rhætian Railway.																
Light rails	...	...	...	1	...	...	7		...	...	...	...	1 ([illegible])	...	...	...

Number of train-miles : 1 064 650.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Yverdon-Sainte-Croix Railway.		Miles												Miles.		English tons.
Light rails	...	1.49	...	...	...	...	...	...	...	...	...	...	...	16.08	...	10.5

Number of train-miles : 50 190.

Lausanne-Ouchy Railway.

No rail breakages in 1928.
Number of train-miles : 55 615.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
CZECHOSLOVAKIA. State Railways.		Miles.			Miles.			Miles.			Miles.			Miles.		
Light rails	7	593.8	7.3	21	429.5	30.4	54	857.8	39.1	60	1 185.2	31.5	71	4 595.0	96.0	...
Medium rails :	3	649.0	2.9	4	245.4	10.1	20	387.9	32.0	27	453.9	37.0	28	3 9.9	48.3	...
Total. . .	10	1 242.8	5.0	25	674.9	23.0	74	1 245.7	36.9	87	1 639.1	33.0	738	4 954.9	92.6	...

Number of train-miles : 69 831 850.
Total number of fractures : 934.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 83.1.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
TURKEY. Smyrna-Cassaba Railway and Extension.		Miles.			Miles.			Miles.			Miles.			Miles.		English tons.
Light rails : of a weight less than 42.5 kgr.	...	7.72	...	...	17.80	...	...	12.40	...	...	125 8	...	2	272.5	4.6	14.3

Number of train-miles : 623 143.
Total number of fractures : 2.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 19.9.

Names of administrations and description of rails	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
URUGUAY.		Miles.						Miles.			Miles.			Miles.		English tons.
Central Uruguay Railway and Allied Companies (*).																
Light rails:																
60.5 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	1	35.396	17.554	15.22
65 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	21	744.951	17.516	15.22
80 lb. per yard	...	104.070	...	...	...	...	...	36.801	...	...	65.600		1	6.738	9.222	15.22
Total	...	104.070	...	...	...	...	...	36.804	...	...	65.600	...	23	787.085	...	...

(*) Year 1927

Number of train-miles : 2 399 355.
Total number of fractures : 23.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 60.1888.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Central Uruguay Railway and Allied Companies (*).		Miles.						Miles.			Miles.			Miles.		English tons.
Light rails:																
60.5 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	...	35.396	...	15.22
65 lb. per yard	...	...	...	...	...	...	...	...	...	...	...	...	10	711.673	8.731	15.22
80 lb. per yard	...	137.350	...	...	...	...	...	28.781	...	...	66.892	...	1	13.466	46.142	15.22
Total	...	137.350	...	...	...	...	...	28.784	...	...	66.862	...	11	760.535	...	...

(*) Year 1928

Number of train-miles : 2 516 060.
Total number of fractures : 11.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles ; 27.662.

NAMES OF ADMINISTRATIONS AND DESCRIPTION OF RAILS	Age of rails: Less than 5 years. Number of fractures.	Less than 5 years. Length of single track of this class.	Less than 5 years. Number of fractures per 1 000 km. or per 625 miles.	5 to 10 years. Number of fractures.	5 to 10 years. Length of single track of this class.	5 to 10 years. Number of fractures per 1 000 km. or per 625 miles.	10 to 15 years. Number of fractures.	10 to 15 years. Length of single track of this class.	10 to 15 years. Number of fractures per 1 000 km. or per 625 miles.	15 to 20 years. Number of fractures.	15 to 20 years. Length of single track of this class.	15 to 20 years. Number of fractures per 1 000 km. or per 625 miles.	More than 20 years. Number of fractures.	More than 20 years. Length of single track of this class.	More than 20 years. Number of fractures per 1 000 km. or per 625 miles.	Maximum axle load
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
YUGOSLAVIA State Railways. (Standard (4 ft.-8 1/2 in.) gauge lines.)		Miles.			Miles.			Miles			Miles.			Miles.		English tons.
Light rails	24	325.6	45.8	22	364.1	37.5	40	409,5	60.6	77	414.5	115.4	1191	2 852.8	259.4	15.74
Medium rails	3	7 5	250.0	5	8 1	384.6	37	112.5	204.4	42	161.6	165.5	41	161.6	157.6	14.76
Total	27	333.1	50.4	27	372.2	45.1	77	522.0	91.6	119	576.1	128.3	1232	3 014.4	253.9	...

Number of train-miles : 23 357 650.
Total number of fractures : 1482.

Number of fractures per 10 000 000 train-kilometres or 6 250 000 train-miles : 395.

	Light rails.	*Medium rails.*
A. — Percentage of fractures in the respective portions of the rails covered by the fishplates	23.3 %	65.8 %
— — — — clear of the fishplates	76.7 %	34.2 %
B. Percentage of fractures according to the appearance of the fracture:		
a) Fresh and clean fracture through the whole of the rail section:		
1° With silvery oval mark	35.8 %	14.6 %
2° Without silvery oval mark	31.5 %	17.8 %
b) Fractures, part of which is old and much rusted, extending to the outer surface of the foot or head of the rail:		
1° When the rusted part is in the foot	11.2 %	17.1 %
2° When the rusted part is in the head	11.4 %	38.3 %
c) Fractures with much rusted portions not extending to the outer surface of the foot or head of the rail	10.1 %	12.2 %
d) Number of pieces into which the rail is broken : 2	95 3 %	85.4 %
— — — — — 3	3.5 %	8.9 %
— — — — — 4	0.6 %	1.6 %
more than 4	0.6 %	4.1 %

CURRENT PRACTICE.

[621 . 152.8 (43)]

The problem of working main lines at very high speeds.

Trial runs of a propeller-driven carriage on the line from Burgwedel to Celle (Germany).

Figs. 1 to 4. pp. 2190 and 2191.

The « Company for the Study of the Technique of Transportation », founded in 1924 at Heidelberg with the object of developing the means of communication at very high speeds on the ground, is now carrying out the first trial runs at high speeds of a rail motor car driven by an air propeller, built by the engineers *Kruckenberg* and *Stedefeld;* these trials are taking place on a line which extends from Burgwedel, near Hannover, in the direction of Celle, a line which has been placed at the disposal of that Company by the Reichsbahn, and without the track having undergone any special repairs.

The idea of working at twice or three times the normal speed on a railway originated already at the end of last century; it has been kept alive by inventors of all nations; but until recently it had hardly got beyond the stage of being an idea and had never been tried out as an industrial proposition in any concrete form. The reader will remember the high speed runs carried out in 1903 with an electric rail motor coach with overhead power supply on the Lichterfelde-Zossen strategic railway, during which a maximum speed of 214 km. (133 miles) per hour was attained. These trials had no result from an economic point of view, owing to the requisite power (3 000 H. P.) being out of proportion to the efficiency attained.

In 1919, Steinitz and Pfeiffer constructed a rail car driven by a propeller which was put into service on the lines of the Reichsbahn, but it was not possible to reach speeds above the normal, owing to the question of brakes. It was in 1924 that the studies of the above mentioned Company started; they first covered the possibilities of constructions of the most varied nature; but finally it was realised that the problem of high speeds on railways could not be approached from all sides at once and they therefore limited their studies to the shape of the vehicle. Preliminary trials were carried out in agreement with the « Aerial Navigation Testing Works » by means of a propeller-driven trial car constructed by these works, *i. e.* by means of a coach conceived for the study of propulsion on the ground by means of an air-propeller. As a result of these trials, they decided on the construction of a propeller-driven car; it was built by the Leinhausen repair shops, placed at the disposal of the Company by the Reichsbahn, and it was only recently that it was shown to the public.

The fundamental principles of the sys-

tem invented by Kruckenberg and his collaborators are : frequent and high speed services. The technical means used to attain this end are : subdivision of the actual trains into much smaller units of transport (rail motor cars), following each other at greater or shorter intervals, at a high speed, on a continuous single line. These methods sometimes refer to the track, sometimes to the vehicles and sometimes to the working methods; at present, the Company has only one of these means in view : the vehicle.

Great speed means above all overcoming the resistance of the air, which increases roughly as the square of the speed, and this determines the shell shape of the vehicle. One of the fundamental ideas of the Kruckenberg car resides in its having the most favourable shape from an aerodynamic point of view. The second factor towards attaining high average speeds resides in the weight of the vehicle. It is indispensable to be able to rapidly start up and slow down. One of the most decisive advantages of the automobile consists in rapidly picking up speed after slowing down; this advantage may equally be applied to a vehicle on rails if we attain the desired lightness in construction, which thus constitutes the second fundamental idea of a fast railway.

The third factor concerns the method of drive. Under present technical conditions, we have to remember that a drive by an air-propeller is the only drive which, combining the requisite facility of operating with safety in working, and a minimum of weight, permits of the transformation of high mechanical powers into high speeds. The vehicle for a high-speed track is thus the rail car with an air-propeller, with a shell-shaped body and of light construction. Finally, there is the question as to running on rails or without rails. If we stop to consider the fact that, in the case of a « two-dimension » mobility the necessarily limited capacity of the driver lessens the possibility of high speeds, we have to vote for the running on rails. In order to obtain high speeds, it is necessary for reasons of safety to adopt a lateral guiding of the vehicle. The ideal realisation of this condition is constituted by the hanging railway, which enables the vehicle to go round curves without lessening speed. It is for this reason that most experimentors in the domain of high speed railways have adopted hanging railways with torpedo-shaped vehicles driven by an air-screw. The particularly high financial outlay resulting from the construction of the line is bound, until something new comes along, to veto this idea, with which a start was recently made in England and where a model of a suspended railway was constructed. The engineer Kruckenberg bases himself on what already exists : his high speed line is a line with a double track, utilising the current type of superstructure.

The new vehicle is shown by figures 1 to 4; the body of the vehicle is supple, shell-shaped, very low down on the rails, so that the wheels do not project more than about 0.50 m. (1 ft. 7 3/4 in.) beyond the body, which is closed underneath. The carriage is 26 m. (85 ft. 3 5/8 in.) long and weighs 18 1/2 tons when empty. It can hold 12 persons when fitted up as a Pullman or 40 to 50 when fitted as an ordinary carriage. The construction comprises a framework of steel tubing with coachwork filling. Speaking on broad lines, the builders have used light-weight alloys, wood, insulating materials and cloth. The windows form a continuous long bay. The footboard which is placed in the middle is raised when the car is in motion and forms part of the doorway. The propeller is situated at the upper rear end of a tapered housing; its axle is slightly inclined on the horizontal, so that the propeller, working a little upwards, not only serves for propulsion but also holds the carriage down against the rails; this arrangement, com-

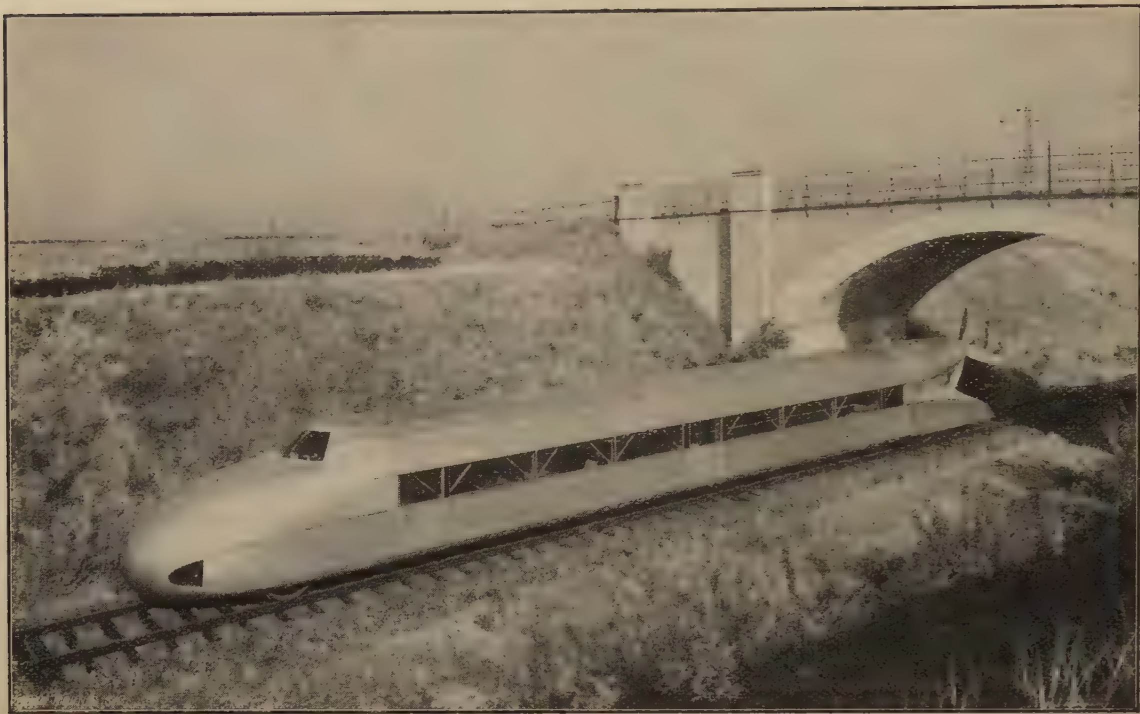

Fig. 1.

Fig. 2.

uckenberg-Stedefeld propeller-driven car.

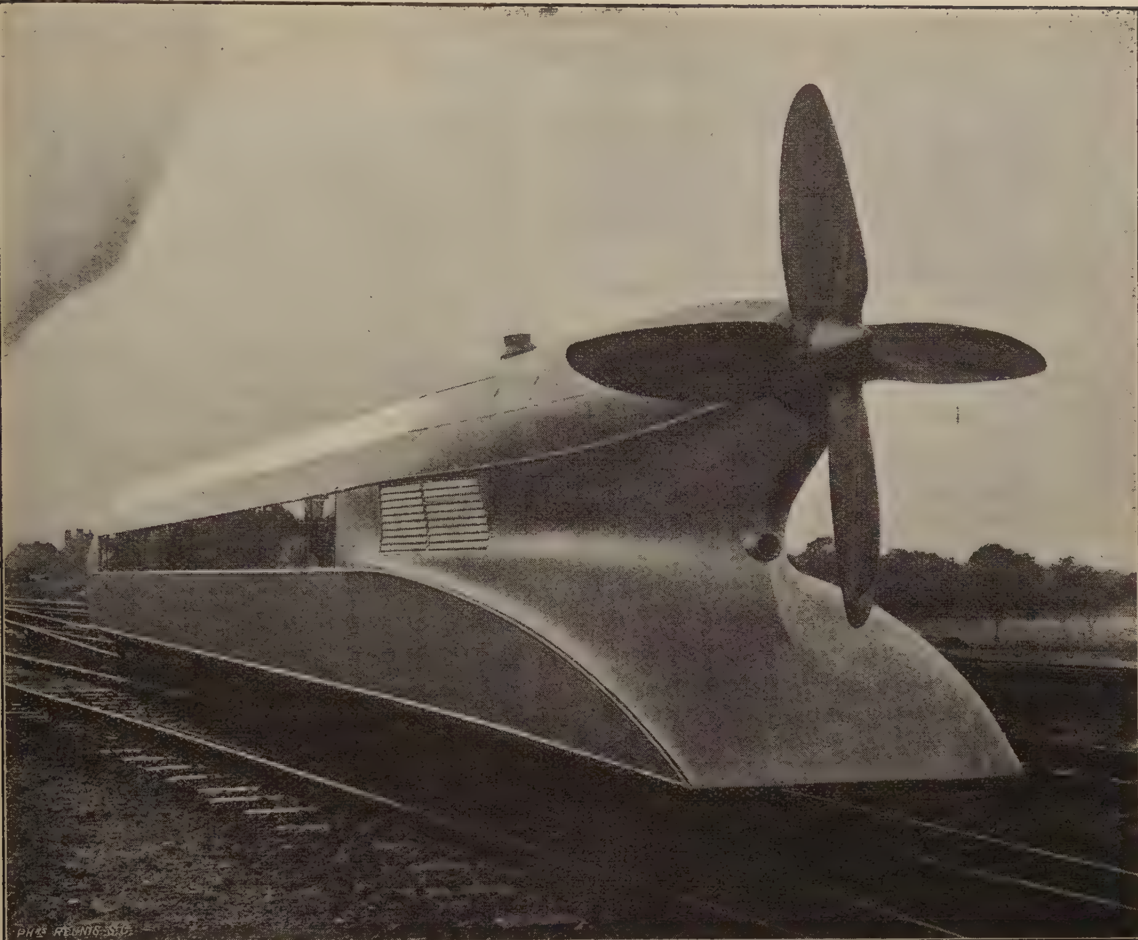

Fig. 3.

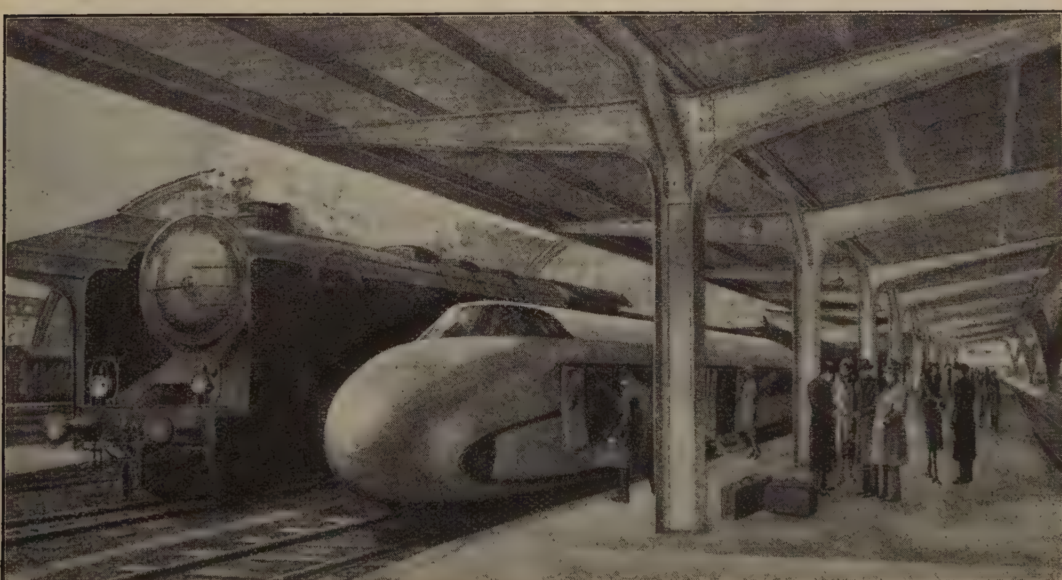

Fig. 4.

bined with the position of the centre of gravity being the very lowest possible, enables us to have satisfactory stability for a comparatively low weight. The propulsion-motor is a 550-H. P. air-engine; it also works a compressor supplying compressed air and two dynamos supplying a battery of accumulators housed in the curved end of the body; the battery feeds the ventilating and lighting installations, as well as an electromotor which moves the vehicle when the main driving motor is stopped. The wheelbase is 20 m. (65 ft. 7 3/8 in.); between the running parts and the body of the vehicle there are, in addition to the springs, rubber buffers. There are two systems of braking : a shoe brake acting on special pulleys and worked by compressed air, and a block brake acting on the tyres of the wheels, worked by hand and which acts as a safety brake.

For starting, the motor is set in motion, with all the brakes on, until it attains the desired number of revolutions. The brakes are then released and the carriage moves off gently, but the speeding up is extraordinarily rapid. After 66 seconds and a distance of 985 m. (3 230 feet) having been travelled, it reaches a speed of 100 km. (62 miles) per hour; after 2 minutes, a speed of 150 km. (93 miles) per hour is reached. The maximum speed attained so far was 182 km. (113 miles). At this speed the brake was applied in order to stop the car at the end of the section of line used for the tests. The starting curve shows, however, that on longer straight lines a considerably higher speed can be reached. The running of the carriage is extremely quiet and it causes no abnormal displacement of air on the track.

At a speed of 150 km. (93 miles) per hour and in calm atmospheric conditions, the necessary working power is 200 H. P. and the consumption of fuel is 20 l. per 100 km. (7 gallons per 100 miles). In comparison, a touring motor car of about 100 H. P. consumes 25 to 30 l. per 100 km. (8.75 to 10.60 gallons per 100 miles).

As we have already mentioned, the vehicle only constitutes the first step in the development of a high-speed railway. We now have to pass on to the track itself, to the question of signalling which must permit of the density of traffic required, etc. In any case, these trials have given us a start which is full of promise; these preliminary tests are all the more significant because they enable one to foresee the time when railways will have all the advantages of the motor car and will go a long way farther towards the final goal to be reached.

NEW BOOKS AND PUBLICATIONS.

[621 .132.8]

WIENER (LIONEL), Professor at the University of Brussels. — **Articulated locomotives.** — One volume (9 × 6 inches) of 628 pages with 213 figures in the text and plates. — 1930, London, W. C. 2, Constable & Co., Ltd, 10-12, Orange Street. (Price : 42 sh. net).

Railway rolling stock with its sturdy design of axles upon which the wheels are keyed, is well designed for running on straight lines. Running round curves calls for special methods, if excessive wear or frictional losses are to be avoided, or if the vehicle is to be able to inscribe itself properly thereon, not to mention the question of safety. Whilst the solutions are relatively simple when applied to coaching or wagon stock — and the best is certainly the bogie — this is not so in the case of the locomotive, which has a large number of axles distributed throughout its length, and in which the boiler and the underframe are necessarily in close connection with the driving mechanism.

The articulated locomotive is one method to which locomotive designers gave early attention : many inventors and builders have devoted patient effort to it.

The type has developed simultaneously with the fixed axle locomotive, and the systems not only tried but applied, are many and various. In recent years, its field of application has been extended.

A book, the author of which is familiar with railways where conditions most often arise to justify the articulated locomotive, and who is known by his earlier studies of the subject, will certainly be well received, all the more so because technical literature, so rich in other directions, offers little on this subject to the reader desirous of accurate information.

What should be understood by « articulated locomotive » ? This essential point is dealt with by the author in the introduction, and on it the classification of the work is based, a methodical and very detailed classification well suited to facilitate the study of so great a variety of types.

The designation applies properly speaking to the locomotive which has two frames or trucks carried each on a certain number of coupled axles and capable of pivoting relatively to the main frame, the actual or supposititious pivots being located on the inside or the outside of the sub-frames. To this definition belong the *Garratt* and the *Golwé*, to mention only the most important. Locomotives which, like the *Mallet*, have two motor trucks, capable of movement relatively to one another, but of which one is considered as rigid because rigidly connected to the boiler or the main frame, are called *semi-articulated* locomotives.

The types which come between these two designations, *Articulated locomotives properly so called* and *Semi-articulated locomotives* form the subject of the two first « books ».

The subdivisions, which we cannot give in detail, are based on the use of one or two motor bogies, on the number of engine units and their type, the method of transmitting the power, the

position of the cylinders, the gauge of the track, etc.

The third book studies those systems in which an attempt has been made to utilise, when desired, the weight of certain carrying axles to increase the adhesion, when the tractive effort developped at the rim of the driving wheels does not exceed the capacity of the boiler.

In the fourth book are described methods developed for utilising for traction purposes other axles which normally only carry dead weight, viz, those of the tender.

In the work thus outlined, and of which we only give the main features, the different systems of articulated locomotives are grouped according to their similarity in principle, and they are studied in the order of their development. Without writing a history, the author has been able, by this method, to mark the principal stages passed through — and they are numerous in this domain — and to credit the inventors with their due share of merit. The most remarkable engines are represented by drawings showing their general arrangements and interesting details.

Numerical tables, to the number of 112, give a synopsis of the leading dimensions of the locomotives in each group, or sub-group.

More than by the details of construction, the attention of railway operators will be held by the information given regarding the use of articulated locomotives, the technical characters of the lines on which they are employed, and the kind of traffic they haul. In the same sequence of thought will be seen the analysis and the discussion of cases where the articulated locomotive can compete advantageously with the locomotive with parallel axles.

The part of the work in which the phenomena of evolution of the systems are brought to notice is not the least interesting one. For example, in the articulated locomotives properly so called, the *Golwé* engine, which appeared after the *Garratt*, reduces the total wheel base by replacing on the main frame the fittings carried by the motor bogies, and by placing the pivots at the centre of the bogies instead of towards the interior; in order to compete against new designs of rigid wheelbase locomotives, the *Mallet's*, departing from the principles of the inventor, are being built as simple expansion engines, this being rendered possible by the use of flexible joints which will stand up to high pressures, and by the application of superheating, which has added to the capacity of the boiler.

This note cannot pretend to review the work which Messrs. Constable & Co. of London have so ably edited. Only by studying it can one appreciate the mass of precise information which the author has collected together, methodically classified, and discussed.

It is a work of the greatest historical, documentary and technical value, this latter being taken in its widest sense, embracing not only the numerous problems involved in the construction of articulated locomotives, but also the more complex question of its application and use.

It will contribute largely to illustrate an interesting aspect of the activity displayed by the builders in order to keep the steam locomotive abreast of modern requirements.

E. M.

ERRATUM.

Bulletin, September 1930 number.

Monthly bibliography of railways, p. 39, 2nd column : The notice regarding Mr. Colson's book « Les travaux publics et les transports » should read :

1930 33 (02 & 656. (02

COLSON (C.).

Les travaux publics et les transports.

Edition définitive du Livre VI du Cours d'Economie politique, professé à l'Ecole des Ponts et Chaussées, remaniée et mise à jour.

Paris (6e), Gauthier-Villars & Cie, 55, quai des Grands-Augustins. Un volume (25 × 16 cm.), 576 pages. (Prix : 50 francs.)

ERRATUM.